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EDITED BY

HENRY WOODWARD, LL.D., F.R.S., Pres. R.M.S., F.G.S.,

LATE OF THE BRITISH MUSEUM OF NATURAL HISTORY;

PRESIDENT OF THE PALÆONTOGRAPHICAL SOCIETY,

VICE-PRESIDENT OF THE ZOOLOGICAL AND MALACOLOGICAL SOCIETIES;

MEMBER OF THE LYCEUM OF NATURAL HISTORY, NEW YORK; AND OF THE AMERICAN PHILOSOPHICAL SOCIETY, PHILADELPHIA; HONORARY MEMBER OF THE YORKSHIRE PHILOSOPHICAL SOCIETY; OF THE GEOLOGISTS' ASSOCIATION, LONDON; OF THE INSTITUTION OF MINING AND METALLURGY, LONDON; OF THE GEOLOGICAL SOCIETIES OF EDINBURGH, GLASGOW, HALIFAX, LIVERPOOL, AND SOUTH AFRICA; CORRESPONDING MEMBER OF THE GEOLOGICAL SOCIETY OF BELGIUM; OF THE IMPERIAL SOCIETY OF NATURAL HISTORY OF MOSCOW; OF THE NATURAL HISTORY SOCIETY OF MONTREAL; AND OF THE MALACOLOGICAL SOCIETY OF BELGIUM.

ASSISTED BY

ROBERT ETHERIDGE, F.R.S. L. & E., F.G.S., F.C.S., &c.

WILFRID H. HUDLESTON, M.A., F.R.S., F.G.S., F.L.S., F.C.S.

GEORGE J. HINDE, Ph.D., F.R.S., F.G.S., &c.

AND

HORACE BOLINGBROKE WOODWARD, F.R.S., F.G.S., &c.

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THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE IV. VOL. X.

No. I.—JANUARY, 1903.

ORIGINAL ARTICLES.

I.—Some Suggestions on Extinction.

By C. W. Andrews, D.Sc., F.G.S., British Museum (Natural History).

THE sudden disappearance of groups of animals, which have existed through long periods of time and have attained a high degree of specialization, is a phenomenon of which many instances will occur to every student of Palæozoology. For instance, to mention only two cases in illustration, we may refer to the disappearance of the Dinosaurs at the end of the Secondary period, and that of the North American Titanotheres in the Miocene. Of the proximate causes of this extinction little is known: they must have been either inherent in the organisms themselves, or have been connected with the relations of the organisms with their environment; probably in every case several factors co-operated to bring about the observed result. In a recent paper by Mr. C. B. Crampton (Proc. Roy. Phys. Soc. Edinburgh, vol. xiv, p. 461) a possible inherent cause of extinction is suggested. It is impossible to do justice to this interesting paper in a short note, but the gist of the argument seems to be as follows:—In the original unicellular organism the possibilities of variation are almost infinite, but as soon as evolution along any line begins, these possibilities are restricted, and become more and more so the more highly specialized the animal is; in short, the potential variation of an organism becomes less and less as specialization advances. Furthermore, under the influence of natural selection, in each generation the individuals which tend to vary in the same direction will survive, while at the same time, as already pointed out, their capacity for variation becomes more and more restricted. The consequence of this will be that the more highly specialized any stock becomes, the more the individuals composing it will come to resemble one another, until at length the same results as arise from close interbreeding, viz., weakening of the stock and, finally, extinction, may follow.

In a paper recently read before the Zoological Society, the present writer, in speaking of the evolution of the Proboscidea, took the

opportunity of pointing out another possible cause of extinction of some groups of animals. It will be observed that in many cases the evolution of a group of animals is accompanied by a simultaneous increase in the bulk of the individuals composing it. The Proboscidea themselves offer a fairly good instance of this tendency, but a better known case is that of the horses. An almost necessary corollary of this increase in bulk is the lengthening of the individual life, or at least what, for our argument, amounts to much the same thing, the lengthening of the time taken to attain sexual maturity. In many Ungulates this increased longevity is indicated by various modifications of the teeth, tending to give them a longer period of wear: generally this end is attained by the increasing hypselodonty of the cheek-teeth. A necessary consequence of the longer individual life will be that in a given period fewer generations will succeed one another, and the rate of evolution of the stock will therefore be lowered in the same proportion. If now the conditions of life undergo change, the question whether a given group of animals will survive or become extinct will depend upon whether it can undergo sufficiently rapid variation to enable it to avoid getting so far out of harmony with its surroundings that further existence becomes impossible. It seems to follow then that the smaller animals, in which the generations succeed one another rapidly, will have a better chance of surviving than the larger and more slowly breeding forms, which at the same time will be still further handicapped if, as is usually the case, they are more highly specialized than the smaller forms, and therefore have a more restricted range of possible variation.

Another result of the increased length of the individual life would be that, during the earlier history of a stock the modification undergone by its members would be more rapid than among the later forms, a phenomenon of which actual instances might be cited, e.g. in the Proboscidea. On the same principle it may perhaps also be explained why certain groups have remained comparatively unchanged through long periods of time. The Sirenia may be a case in point, though no doubt in this case, among other factors, the comparative stability of the conditions of life has had much to do with the conservative character of the group.

II.—Woodwardian Museum Notes: On some Wenlock Species of *Lichas*.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE I.)

THE entire collection of Wenlock fossils made by T. W. Fletcher, Esq., which is now in the Woodwardian Museum, affords unsurpassed facilities for studying the material on which a large number of species of trilobites were founded. Particularly is this the case with those of the genus *Lichas*, and a recent examination of the types and other specimens which Fletcher used in writing his paper "Observations on Dudley Trilobites" (Q.J.G.S., 1850,

vol. vi, pp. 235–239, pls. xxvii and xxvii *bis*) has led me to make the following notes upon them. I have also had the privilege, through the kindness of Dr. Arthur Smith Woodward, F.R.S., of examining the specimens in the British Museum (Nat. Hist.), Cromwell Road.

LICHAS (CORYDOCEPHALUS) ANGLICUS (Beyrich). (Pl. I, Figs. 1, 2.)

Lichas Bucklandi, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 235, pl. xxvii, figs. 2, 3, 4, ? 5, 5*a* (*non* figs. 1, 1*a*); pl. xxvii *bis*, figs. 1, 1*a*, 1*b*.

There is considerable variation in the degree of development of the spines on the pygidial margin of this species. A similar variation is noticeable in *Cheirurus bimucronatus* and the species of *Acidaspis* from the same beds. The relative length of the axis of the pygidium also shows marked individual differences. Fletcher figured one specimen (*op. cit.*, pl. xxvii, figs. 5, 5*a*) which he described as a young individual, and probably it should be regarded as such. But there are two well-marked and constant varieties which show definite features separating them from the type-form, and in fact are more abundant than the latter.

(i) The first variety, which may be called *wenlockensis* (Pl. I, Fig. 1), has a pygidium which is subquadrate in outline, and has almost a straight posterior border. The nine marginal spines are unequally developed; the first two pairs are strong and of equal size, but the third pair, situated at the lateral corners of the posterior margin, are much stouter and larger, projecting nearly straight backwards behind the pygidium. Between them lie three equidistant smaller spines, the median one of which is generally the largest. Minute prickles are in some specimens noticeable along the margin between the spines. A shallow groove parallel to the posterior edge of the pygidium and marking off a distinct border, but not crossing the post-axial median piece, is present on the lateral lobes behind the second pair of pleuræ. A similar though fainter groove is distinguishable on the pygidium of the type-specimen and type-form figured by Fletcher (*op. cit.*, pl. xxvii *bis*, figs. 1, 1*a*), and in the other specimen regarded by him as a young individual (pl. xxvii, figs. 5, 5*a*), but no mention of it is made in his description.

The posterior half of each of the two pairs of pleuræ behind the pleural furrow in the variety *wenlockensis* is also remarkably narrow in comparison with the anterior portion. In Fletcher's figure of the type-form the posterior portion is made broader than it is in reality in the specimen.

From the above remarks it will be seen that the distinguishing features of this variety are the general shape of the pygidium and the development of the lateral spines. The thorax and head-shield in complete specimens show no points of difference from the type-form which can be established as constant.

(ii) The second variety (Pl. I, Fig. 2), of which there are also complete specimens in the Woodwardian Museum, likewise exhibits its distinctive features only in the pygidium. In this form there are only eight marginal spines, the posterior median one being absent or merely represented by a small prickle. The shape of the pygidium

is subquadrate rather than semicircular; the first two pairs of lateral spines (i.e. the pleural points) are moderately developed, and equal or subequal in size; the third pair of spines is developed as in the variety *wenlockensis*, being stronger and stouter than the others; the fourth pair of spines is reduced in size, and slender, and usually rather closely placed to the third pair, leaving the median portion of the posterior margin free of spines and only armed with small prickles. In other respects this variety resembles that above described. Both differ from the type-form by the subquadrate rather than semicircular shape of the pygidium, and by the specially strong development of the third pair of marginal spines. This second variety may be termed *obtusicaudatus*.

Salter attributed both these varieties of *L. anglicus* to *L. hirsutus*, as his labels and Catalogue show (Cat. Camb. Sil. Foss. Woodw. Mus., p. 130, *a* 961, *a* 963, *a* 964), but they differ completely from it, as a reference to Fletcher's figured specimens and the descriptions of that species at once proves.

The 'angularity' of the head-shield upon which Fletcher remarks in one specimen (figs. 3, 3*a*, pl. xxvii) is caused by the sudden bend in the front margin of the free cheek, just outside the point where the facial suture cuts the border. This projection of the middle portion of the head-shield is very well marked in some specimens of the type-form and in the variety *wenlockensis*, and is indicated in the restoration of the front border by Fletcher (*op. cit.*, pl. xxvii *bis*, fig. 1*a*). It appears to be a characteristic and constant feature, being noticeable wherever that portion of the head-shield is preserved.

LICHAS (CORYDOCEPHALUS) HIRSUTUS (Fletcher). (Pl. I, Figs. 3, 4, 5.)

L. hirsutus, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 236, pl. xxvii, figs. 6, 6*a*; pl. xxvii *bis*, figs. 2, 2*a* (*non* pl. xxvii, figs. 7, 7*a*).
L. Bucklandi, Fletcher (*pars*): ibid., pl. xxvii, figs. 1, 1*a*, 1*b* (*non cet.*).

There are three specimens ascribed to this species by Fletcher and figured by him, all of which are in the Woodwardian Museum. Excluding the remarks on the specimen figured on pl. xxvii, figs. 7, 7*a*, the description of the species given by Fletcher is fairly accurate and complete so far as it goes, but the figures (pl. xxvii, figs. 6, 6*a*; pl. xxvii *bis*, figs. 2, 2*a*) show such differences that they might be thought to represent distinct species. The specimens, however, from which these figures were drawn are in reality closely similar, and do not exhibit more than the customary amount of variation. The specimen on which figs. 6, 6*a*, pl. xxvii were founded is so imperfect that it shows Fletcher used other specimens together with it in order to draw up his description of the species. There is no distinctly raised border round the pygidium, the appearance in Fletcher's figured specimen (pl. xxvii, fig. 6*a*) being due to unequal crushing. Other specimens show that the relative length of the axis slightly varies, and also the number of tubercular rings upon it.

A well-preserved complete specimen in the Woodwardian Museum showing head, thorax, and pygidium attached, and several other less

perfect specimens, enable me to give a complete description of the species, and render possible the identification of isolated head-shields, previously of doubtful specific position.

Diagnosis.—Head-shield broadly parabolic, more than twice as broad as long, swollen centrally, bent down at sides and strongly in front. Glabella elevated, convex, large, broader than long; greatest width across middle third. Central lobe long, subcylindrical with parallel sides between anterior bicomposite lateral lobes, slightly expanded in front, embracing front end of these lobes; defined posteriorly by strong curved transverse furrow at level of second lateral furrow. Anterior lateral lobes rather swollen, oval but slightly pointed behind; each as broad as central lobe; extend three-fourths the length of the glabella; are defined externally by strong furrow. Middle and basal lobes obsolete, their place being occupied by a subtriangular, uniformly swollen surface, not differentiated or marked off from the fixed cheek, except behind the eye, where the posterior portion of the axal furrow is faintly developed.

Between the central lobe and neck-ring is a narrow post-central lobe depressed below the level of the central and lateral lobes, and defined laterally by the weak backward continuation of the first lateral furrows to the neck-ring; three conspicuous large isolated tubercles usually ornament it.

First lateral furrows curve inwards strongly from anterior point of origin, sweeping round front end of anterior lateral lobes; then run backwards to transverse furrow with increasing strength and almost parallel to each other, behind which they diverge and are feebly continued to neck-ring.

Axal furrows strong, curved outwards, defining outer border of anterior lateral lobes; not continued behind second lateral furrows, which at level of eyes pass imperceptibly into them. Close to the neck-ring a faint furrow on each side represents the posterior portion of the axal furrows.

Second lateral furrows form a continuation inwards of the axal furrows round the base of the anterior lateral lobes, joining first lateral furrows at angle of 75°–90°. Transverse central furrow runs across middle of glabella as continuation of second lateral furrows with equal strength, but with independent backward curvature. Occipital ring arched forwards, swollen, broadest in middle, generally with median tubercle.

Fixed cheeks triangular, swollen towards inner portion, not marked off in middle from glabella; posterior edge straight, horizontal at right angles to axis of glabella, but bending sharply forward at outer angle at about 130°. Eye-lobe moderate, prominent, horizontal, at level of second lateral furrow. Neck-ring on posterior margin elevated, narrow, ornamented with single row of large tubercles.

Facial suture makes a sharp bend outwards behind eye, curving thence backwards to cut lateral margin behind spine.

Free cheek narrow, elongated, triangular, inner portion swollen, bearing prominent elevated eye of moderate size. Middle of lateral

margin furnished with strong short outwardly projecting spine, curving slightly backwards.

Head-shield in all parts (including spines) ornamented with large tubercles, not closely set, with smaller ones interspersed.

Thorax composed of eleven segments. Axis moderately convex, nearly as wide as pleural portions, cylindrical for first six or seven rings, then tapering gradually backwards to pygidium. Axal furrows well-marked. Axial rings narrow, rounded, with narrow articulating band.

Pleuræ narrow, rounded, cylindrical, with free pointed extremities; horizontally extended to fulcrum, which is situated at about half their length, then bent downwards and slightly backwards. Narrow flattened band on front edge. Each thoracic segment bears a single row of a few large equally-spaced tubercles.

Pygidium broadly parabolic, usually slightly broader than long. Axis convex, subcylindrical or slightly tapering, bluntly rounded at posterior end; extends about two-thirds the length of pygidium, and occupies about the middle third of width. One strong complete axial ring at front end with narrow articulating band on front edge, followed by 3–5 narrow transverse rows of tubercles in middle portion of axis; the first one or two rows are separated by more or less distinct furrows. Posterior end of axis abrupt, blunt, not circumscribed by furrow, but continued posteriorly by narrow, depressed, tapering post-axial median piece, which becomes parallel-sided and extends to posterior border between third pair of marginal spines.

Lateral lobes flattened, slightly bent down, with three pairs of large spines projecting beyond the margin and numerous minute spinules or prickles. Two pairs of well-defined pleuræ curving backwards; each pleura marked by median furrow dividing it into two unequal portions, of which the posterior is the narrower and more elevated. Each pleura is produced beyond pygidial margin into short free point, forming thus the two anterior pairs of marginal spines, which also bear small lateral prickles (only occasionally preserved). Pleuræ separated by well-marked interpleural furrows curving backwards, of which the first makes an angle of about 30° with the front margin, and the second makes an angle of about 60°–70° with the same. Between the second pleuræ and the post-axial piece is a triangular, irregularly tuberculated area on each side with no furrow upon it. The posterior pair of spines are approximate and directed straight backwards, and are generally about equal in length to the second pair, from which they are removed by about twice the distance that they are from each other.

MEASUREMENTS.

	mm.
Length of trilobite	21·0
Length of head-shield	6·5
Width of head-shield (from tips of genal spines)	18·0
Length of thorax	7·5
Length of pygidium...	7·0
Width of pygidium	9·0

Remarks.—The head-shield shows considerable resemblance to that of *L. anglicus* (Beyr.); but the latter may be distinguished by (1) the more quadrato-oval shape of the anterior lateral bicomposite lobes of the glabella, owing to the second lateral furrow meeting the first lateral furrow at a right angle, (2) the greater size of the post-central lobe of the glabella, (3) the small outward bend in the first lateral furrows in the middle of the central lobe, (4) the absence of the basal portion of the axal furrow, (5) the smaller lateral expansion of the anterior end of the central lobe of the glabella, (6) the different shape of the free cheek, and (7) the regular curve described by the posterior margin of the head-shield. A comparison of Fletcher's figure (pl. xxvii *bis*, fig. 1*a*) of *L. anglicus* plainly shows the points of difference.

The glabella in *L. anglicus* is also generally of rather less width, but is somewhat longer; and the head-shield is not so bent down in front, nor so swollen centrally.

In the pygidium we see in *L. hirsutus* much resemblance to *L. Haueri* (Barr.),[1] and the head-shield, with the exception of the transverse post-central furrow, is likewise somewhat similar. The peculiar laterally angulated outline of the posterior margin of the head-shield and position of the spine on the free cheek is likewise met with in *L. Haueri* and in other Bohemian species.

The head-shield referred by Fletcher to *L. anglicus* (pl. xxvii, figs. 1, 1*a*, 1*b*), but mentioned as being of a slightly unusual form (p. 236), should be attributed to *L. hirsutus*, with which it agrees in all essential features.

Barrande (*op. cit.*, p. 602) considered that *L. hirsutus*, Fletcher, was identical with his *L. palmata* (Barrande, *op. cit.*, p. 599, pl. xxix, figs. 1–13), but remarks that one of Fletcher's specimens (shown in fig. 5, pl. xxvii, Q.J.G.S., 1850, vol. vi) represents a different form to which the specific name *L. hirsutus* must be restricted. Probably Barrande meant fig. 7 instead of fig. 5, for the latter is attributed by Fletcher to *L. Bucklandi* in his explanation of plate xxvii. *L. hirsutus*, Fletcher (excluding fig. 7, pl. xxvii), however, differs from *L. palmata* in numerous points, the most important of which are the absence of the well-defined middle glabellar and occipital lobes, and in the pygidium the presence of only one strong axial ring followed by several incomplete rows of tubercles. These features are amply sufficient to separate it specifically.

Lichas (Corydocephalus) hirsutus, var. tuberculatus (var. nov.).
(Pl. I, Fig. 6.)

Several specimens of a *Lichas* from the Wenlock Limestone or Shale of Dudley show points of difference from the type-form of *L. hirsutus* almost sufficient to constitute a distinct species. In the head-shield the basal portion of the axal furrows is wanting, and the fixed cheeks are completely confluent with the middle lateral portions of the glabella; there is one conspicuously large tubercle on the middle of the fixed cheek, and the eye-lobe projects laterally in a very prominent manner; the occipital ring also bears a large

[1] Barrande: Syst. Sil. Bohem., vol. i, p. 604, pl. xxviii, figs. 38–44.

median tubercle. There are only ten segments recognizable in the thorax in the one complete specimen which I have examined, but this probably only indicates immaturity. The pygidium has a large prominent central tubercle near its posterior end; the transverse rows of tubercles on the axis behind the first ring are very indistinct; the post-axial piece is very short and ill-defined. The two pairs of pleuræ have their free ends more elongated than is usual, the second pair indeed projecting back behind the posterior end of the pygidium and behind the third pair of spines, which are very short and blunt.

Fletcher labelled one of these specimens *L. Bucklandi* (= *L. anglicus*), but Salter labelled another (*a* 963) *L. hirsutus*. From the presence of several specially large tubercles this variety may be termed *tuberculatus*.

LICHAS (CORYDOCEPHALUS), sp.

L. hirsutus (Fletcher), "young": Q.J.G.S., 1850, vol. vi, pl. xxvii, figs. 7, 7*a*.

The pygidium figured by Fletcher as belonging to a young individual of *L. hirsutus*, "from the great similarity in the arrangement of the tubercles on the axis and sides," shows such important differences that it does not seem possible to regard them as merely marking a stage of growth in an individual of this species. The pygidium is semicircular, with three pairs of marginal spines of subequal size. The axis is very broad, blunt, and subconical, reaching fully three-fourths the entire length of the pygidium, and occupying considerably more than its middle third. There is one strong ring at the front end of the axis, followed by two or three much narrower and fainter rings marked by tubercles. There is no distinct post-axial piece. The axal furrows are strong and deep. There are two pairs of pleuræ on each side (not three 'ribs' as Fletcher states), curved backwards, and ending in short stout, backwardly directed free points on the margin. The surface of each pleura is divided down the centre by a strong median furrow, equal in strength to the interpleural furrows; the anterior and posterior parts of each pleura are of equal size and elevation, and each is ornamented by a single row of large tubercles. The posterior pair of spines is rather shorter than the first and second pairs, and its members are twice as closely approximated to each other as they are to the second pair of spines. A few large tubercles are somewhat regularly disposed on the axis and the portions of the lateral lobes behind the second pleuræ.

The margin is strongly and sharply incurved below, and is marked by concentric raised striæ, which also cross the under-surface of the spines.

MEASUREMENTS.

	mm.
Length of pygidium	4
Width of pygidium	7
Width of axis	3

REMARKS.—It is possible that the specimen above described belongs to an immature individual of some species, though probably not to *L. hirsutus*. It is advisable, therefore, in the absence of further evidence to leave it unassociated with any of the described species, and to refrain from considering it a new species.

LICHAS (DICRANOPELTIS) WOODWARDI, sp. nov.[1] (Pl. I, Figs. 7, 8.)

L. Barrandii, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 238, pl. xxvii, fig. 10 (*non* pl. xxvii *bis*, fig. 5).

The description which Fletcher gave of the species which he called *L. Barrandii* corresponds exactly with his fig. 5, pl. xxvii *bis*, and with the two specimens on which this was founded, but it does not at all agree with the figure on the preceding plate (fig. 10, pl. xxvii), nor with the specimen which it represents, and the only point in the description which is borrowed from it refers to the concentric striation of the under side, which is not seen on the other specimens. A suspicion that two species have been confounded at once arises, and an examination of the type-specimens which are in the Woodwardian Museum confirms it. Moreover, the type-specimen represented in fig. 10, pl. xxvii shows only the inner surface of the shell, but another showing the actual outer surface in relief has come into our possession with the remainder of Fletcher's collection presented in 1897, and it was labelled by Fletcher himself *L. Barrandii*. From this material a fairly complete description of this new species can be given, so far as the pygidial characters are concerned.

Pygidium broadly parabolic; ratio of length to width as 3 : 4. Axis rounded, convex, slightly elevated above side-lobes; nearly one-third the width of the pygidium at front end; short, broad, not as long as broad; sides converge posteriorly at angle of about 35°; abruptly truncated at posterior end by straight transverse furrow; bears two well-marked continuous rings at anterior end. Axal furrows well-marked, nearly straight. Transverse furrow defining termination of axis weak in centre, strongly impressed at sides.

Lateral lobes flattened, nearly horizontally extended, furnished with six pairs of furrows of equal strength; each lobe consisting of three broad foliaceous pleuræ with free falcate, backwardly directed ends. First two pleuræ on each side complete, and well-defined by strong interpleural furrows of equal depth, the first furrow making an angle of about 30° with the front edge of the pygidium, and the second an angle of about 60°. First pleura marked by diagonal furrow which runs parallel to the first interpleural furrow, but dies out before reaching the free point of the pleura. Second pleura marked by similar furrow starting from axal furrow at the point of origin of first interpleural furrow, and running thence parallel to second interpleural furrow, but dying out before reaching free point.

Axal furrows continued backwards behind axis, at first with same angle of convergence and then almost parallel to each other, but disappearing at some distance from the posterior margin of pygidium. The post-axial median piece enclosed between them is narrow, and slopes down rapidly to level of side-lobes. Third pair of pleuræ

[1] This species is mentioned by the author in his paper on the genus *Lichas*: Q.J.G.S., 1902, vol. lviii, pp. 72 and 82.

between second pair of pleuræ and post-axial median piece; each third pleura ends in backwardly directed free point, and is crossed by diagonal furrow making an angle of about 80°–90° with front edge of pygidium. Free points of third pair of pleuræ approximate (not well preserved); margin of pygidium incurved, and shows on under-surface concentric equidistant raised thread-like lines.

Ornamentation consists of large round tubercles of two or three graduated sizes, not very closely set. Owing to the breaking off of the heads of the larger tubercles (which are hollow), circular pits with a raised margin are left as cicatrices.

MEASUREMENTS.

	I (Fletcher's figured specimen).	II.
Length of pygidium	? ...	c. 31 mm.
Width of pygidium	46 mm. ...	40 ,,
Width of axis at front end	15 ,, ...	13·5 ,,
Length of axis	11 ,, ...	9·0 ,,

REMARKS.—This species differs from *L. Barrandii* (Q.J.G.S., 1850, vol. vi, pl. xxvii *bis*, fig. 5) by the following features: (1) greater relative length of pygidium, (2) narrower and shorter axis, (3) only two axial rings, (4) no axial tubercle, (5) straight transverse posterior furrow defining end of axis, (6) longer post-axial median piece, (7) less backwardly curved pleuræ, (8) course of furrows on lateral lobes, (9) coarser tuberculation.

The pygidium of *L. scaber* (Beyr.) bears a considerable resemblance to that of *L. Woodwardi*. It may also be mentioned that the ornamentation of *L. Grayi*, of which only the head-shield is known from the Wenlock Limestone, is somewhat similar.

LICHAS (DICRANOPELTIS) BARRANDEI, Fletcher (emend.).

Lichas Barrandii, Fletcher (*pars*): Q.J.G.S., 1850, vol. vi, p. 238, pl. xxvii *bis*, fig. 5 (*non* pl. xxvii, fig. 10).

Fletcher's diagnosis of this species, with the exception of the statement that "the incurved under-portion is concentrically striated," which cannot be verified with our present material, applies to fig. 5, pl. xxvii *bis*, and does not need any amplification. It may, however, be remarked that the figure is partly a restoration based on two nearly complete specimens (*b* 28, *b* 29 in Salter's Catalogue), the measurements of which are as follows:—

	I (*b* 29).	II (*b* 28).
Length of pygidium	20 mm. ...	18 mm.
Width (at front end) of pygidium ...	? ...	24 ,,
Width of axis (at front end)	13 ,, ...	11 ,,
Length of axis...	10 ,, ...	?

It is unfortunate that of this species only the pygidium is known at present. In one of the specimens (I) a faint transverse furrow, incomplete in the middle, defines the posterior end of the axis, recalling the much stronger furrow seen in *L. Woodwardi*. Fletcher does not mention it, and it appears to be obsolete in the better

preserved specimen (II), which he used chiefly in drawing fig. 5, pl. xxvii *bis*.

Lichas (Dicranopeltis?) Salteri, Fletcher.

L. Salteri, Fletcher: Q.J.G.S., 1850, vol. vi, p. 237, pl. xxvii, figs. 9, 9*a*; pl. xxvii *bis*, fig. 4.

Lindström[1] records this species from Gotland, and believes that *L. laticeps*, Angelin (Pal. Scan., 1854, pp. 70, 72, t. xxxvii, figs. 8, 8*a*, *non* t. xxxviii, fig. 5), and *L. gibbus*, Angelin (Pal. Scan., p. 71, t. xxxvii, fig. 1, pygidium only), are synonyms. The rows of large tubercles on the glabella and side-lobes are held by Lindström to be the particular characteristic of the species; and unfortunately no part but the head-shield, and that incomplete, is known from the Wenlock Limestone. It is impossible to feel on safe ground in assigning any of the isolated pygidia of this horizon to *L. Salteri*, but Lindström[2] considers the pygidium figured by Angelin (*op. cit. sup.*) as *L. gibbus* as probably belonging to this species, and describes it as possessing a linear axis narrowing posteriorly, furnished with about eleven segments, of which the posterior ones are inconspicuous; a narrow prolongation extends behind it towards the margin. Three small pleura-like ribs are given off on each side from rather in front of the middle of the axis. There is a raised border round the pygidium, and from it short, backwardly directed spines project near the terminations of the ribs. Between the two posterior ones are three pairs of small spines, one of which projects from the axis. It is to be regretted that Lindström did not give a figure of this specimen, as Angelin's figure leaves much to be desired, and it is difficult to form an adequate idea of the pygidial characters from the description.

The old generic designation *Trochurus* is revived by Lindström for this species, and applied also to *T. pusillus*, Angelin, and *T. Bucklandi*, Milne Edwards (= *L. anglicus*, Beyrich). Beyrich, however, in 1846 (Untersuch. über Trilob.) declared that this name, which he had instituted in 1845 (Ueber Boh. Trilob., p. 31, fig. 14), should be allowed to drop, as the genus had been founded on a specimen consisting of portions of two distinct trilobites (i.e. a head of *Staurocephalus Murchisoni* combined with a pygidium of *L. speciosus*, Beyr. [= *L. palmata*, Barrande]). Barrande (Syst. Sil. Boh., vol. i, p. 603) points out this fact, and also rejects for this reason the specific name *L. speciosus*, which Beyrich had given in 1845 to the composite form. It accordingly appears inadvisable to revive the name *Trochurus* under any form. Beyrich himself employed in 1846 Goldfuss' earlier name *Arges* (1839) for his species *L. speciosus* (= *L. palmata*, Barr.), but, as previously pointed out by the present writer,[3] this name is preoccupied.

[1] Lindström: Gotl. Silur. Crust. Ofv. K. Vet. Akad. Forhandl., 1885, No. 6, p. 60 (*Trochurus Salteri*); List of the Fossils of the Upper Silurian Formation of Gotland, Stockholm, 1885, p. 3 (*Trochurus Salteri*).

[2] Gotl. Silur. Crust. Ofv. K. Vet. Akad. Forhandl., 1885, p. 60.

[3] Q.J.G.S., 1902, vol. lviii, p. 60.

EXPLANATION OF PLATE I.

FIG. 1.—*Lichas* (*Corydocephalus*) *anglicus*, var. *wenlockensis*. Outline restoration of pygidium. × 3.
,, 2.—*L.* (*Corydo.*) *anglicus*, var. *obtusicaudatus*. Outline restoration of pygidium. × 4.
,, 3.—*L.* (*Corydo.*) *hirsutus*. Specimen with eleven thoracic segments. × 2½ (partly restored). Woodw. Mus.
,, 4.—Ditto. Specimen with eleven thoracic segments. × 2½ (partly restored). Brit. Mus.
,, 5.—Ditto. Outline restoration of pygidium from Fletcher's type. × 3.
,, 6.—Ditto. Var. *tuberculatus*. × 3. Woodw. Mus.
,, 7.—*L.* (*Dicranopeltis*) *Woodwardi*. × 1½. Woodw. Mus.
,, 8.—Ditto. Nat. size. Figured by Fletcher as *L. Barrandii* (Q.J.G.S., vol. vi, pl. xxvii, fig. 10). Woodw. Mus.

III.—On the Original Form of Sedimentary Deposits.[1]

By the Rev. J. F. Blake, M.A., F.G.S.

THE form of the deposits that are taking place on the sea-bottom at the present day is one of the essential elements required to be known when we wish to interpret the submarine contours, as throwing light on the submergence or elevation of the land in late geological times, or when we propose to use the variation of thickness of the strata deposited during any epoch as an indication of the position of the shore-lines at that time.

In the case of deposits in small or temporary masses of water, their form and arrangement may sometimes be observed directly; but in the case of the deposits in the sea, where we can neither remove the water nor make borings beneath it, we can only avail ourselves of theoretical considerations.

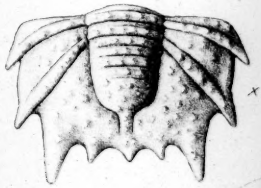
It might have been expected that the original form of various sedimentary deposits would have been considered in detail long ago, but as a matter of fact the few writers who have touched upon the question have mostly been content with the assumption that deposits taken as a whole are thickest near the source of supply, and the figures given in illustration of the arrangement of various kinds, and thereby the shape of each, are remarkable for their variety.[2]

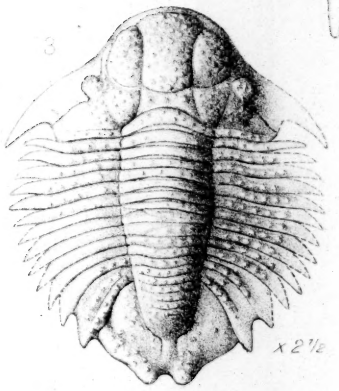
As the theoretical results at which I have arrived differ fundamentally from the ordinary assumptions, it is to be hoped that some one will be able to point out the fallacy, if any, which has led me astray, and to explain more satisfactorily the observed features which appear to confirm the theory. It will be seen, however, that it is just those writers who have paid most attention to the matter who approach most nearly to agreement with my results.

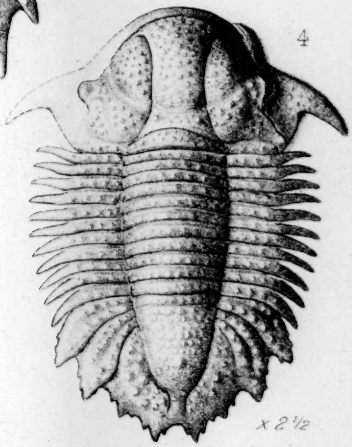
The actual form of any deposit on the sea-bottom, supposed, for the sake of argument, to be flat, will depend first upon the forces to which the material is subject, and secondly upon the nature of the

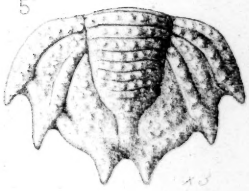
[1] A paper read at the Meeting of the British Association, Belfast, September, 1902.

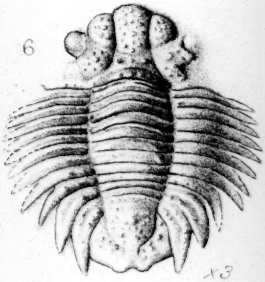
[2] See Godwin-Austen, Q.J.G.S., vol. vi, p. 82, fig. 2 (1850); Hull, Q.J.G.S., vol. xviii, p. 135, fig. 4 (1862); Green, Lectures on Coal, p. 9 (1878), and Geology, p. 211 (1882); Page & Lapworth, Introductory Textbook, p. 59, fig. 22 (1888); Marr, Principles of Stratigraphical Geology, p. 117, fig. 13 (1898); Watts, Geology for Beginners, p. 73, fig. 47 (1898).

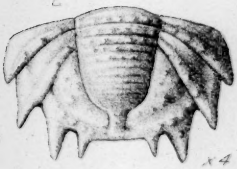


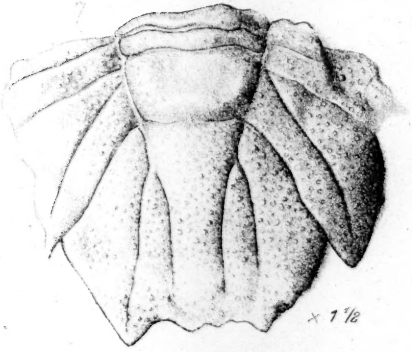


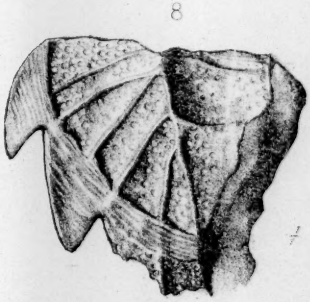












G.M. Woodward del. et lith. West, Newman imp.

Some Wenlock Species of Lichas.

material in relation to those forces. The forces are three, viz., the horizontal currents, the vertical force of gravity, and the resistance of the water to the sinking through it of the material. Of the horizontal currents the most important is that produced by a river running out to sea in a direction perpendicular to the shore. This alone, except the underdrift from breakers, brings *new* materials to form an *original* deposit in the sea. Outward flowing tides, however, act ultimately in a similar manner, and may be considered to belong to the same type, the other type being the currents parallel to the shore, which only shift material already brought. The vertical force of gravity produces a downward velocity which at every instant is combined with the horizontal velocity to make the path of any particle of material a downward sloping one, and the momentary paths combine into a curved one, which becomes vertical when either the particle sinks below the bottom of the current or the current itself is destroyed. The former limit will usually be the first to be reached. The resistance of the water to the sinking of the material depends (1) on the coefficient of viscosity of the water, and (2) on the area, projected on a horizontal plane, of the sinking particle; but for our present purpose we need only note that it is known to be increased by a horizontal movement of the water, and therefore is continually being diminished as the water comes gradually to rest.

In relation to these forces only two kinds of material need be distinguished, namely, that of which the particles are too light, small, or flat to sink in water having the velocity of the given current, and which are carried in suspension so long as that velocity is maintained; and that which consists of stones or grains which are only pushed along the bottom. There may be some small portion of the material on the verge between these two classes, which will pass from the first to the second on a slight decrease of velocity, but as a rule the classes are distinct. The rubbing together of two stones, which is the origin of all detritus, results in the formation of very fine powder and the diminution of the size of the stones; and it is only when the stones are diminished to a floating size that they can form part of the suspended matter. The resulting form of the deposit in these two classes, though similar, will arise from different causes.

In the case of material pushed along the bottom, the result is very simple, and is scarcely a matter of dispute. None of it will be carried further than the spot where the water becomes deeper than the current. When there is no bottom to support the material it will fall to rest at once, and fill up the space between the bottom of the current and the bottom of the sea, as in Fig. 1.

The deposit grows by additions along *a–b*, and not along *a–F*, just in the same manner as a railway embankment grows, by tipping material over the end; it will be truncated at the end according to the angle of rest of the material in sea-water, and if the sea-bottom slopes gradually down it will be thickest at the point of its lower termination, that is, *at the point which is farthest from the source of*

supply. This original theoretical form will, of course, be much modified in nature by various other causes, but it will not, on the average, be obliterated.

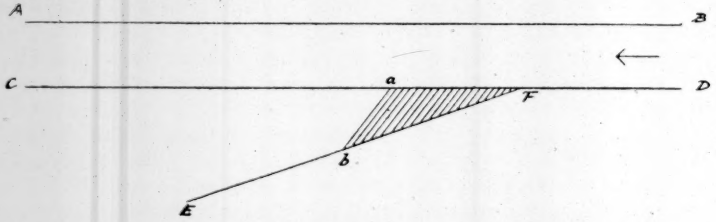


FIG. 1.—SECTION OF DEPOSIT OF LARGE DETRITUS AT A RIVER'S MOUTH. *A–B* = sea-level; *C–D*, bottom of the current; *E–F*, shelving bottom of the sea; *a–b–F*, section of the deposit.

Now consider the case of the material in suspension, which is the crux of the whole question. So long as the current is strong enough to push along the heavier particles, it is *a fortiori* strong enough to hold up the lighter in suspension. None, therefore, of the latter (except the diminished stones), will *begin* to sink till after the former has settled, and the whole of the finer deposit will lie seaward of the coarser. At a later time the coarser deposit may grow over the earlier part of the finer, but the two parts that are brought by the same body of water will always be initially separate. As the stream may possibly contain in suspension particles of various rates of sinking, we must consider these separately, and temporarily assume for working out the result that the rate of sinking of the part considered is constant in water of given velocity. The velocity of the stream on reaching the sea will be at last reduced to the stage at which sinking commences, and thereafter it will be continually more and more reduced till it becomes practically zero. We have seen that the result of this diminution of velocity is twofold. It causes the sediment to fall more vertically and against a smaller resistance.

Now the sediment may be considered as arriving in a series of vertical sheets transverse to the stream, and each sheet, as the particles in it sink down, will be spread out horizontally on the bottom. Let us take a section of such a sheet, *a–e*, Fig. 2, and trace the course of the particles in it across a series of equal divisions, in each of which the horizontal velocity is assumed to be constant, so that the paths of the particles in each are all parallel; but in successive ones these velocities are decreased, so that the paths, though still parallel amongst themselves, will be more inclined than in the preceding division. Selecting particles which thus arrive at points equidistant from each other, as b'', c'', d'', so that the line $b''c'' = c''d''$, since $d'd''$ is more inclined than $c'c''$, it follows that $c''d'$ is greater than $b''c'$, and therefore that dc is greater than bc. In other words, if the sediment is uniformly distributed in *ae* a larger proportion of it will be deposited between d'' and c'' than between the preceding equally distant points c'' and b'', or the deposit

from a uniform vertical sheet of sediment will continually thicken distally, till the highest particle reaches the bottom, when it will end abruptly. The deposit thus falling from the bottom of the current will be reproduced at any depth where it reaches the solid bottom of the sea below.

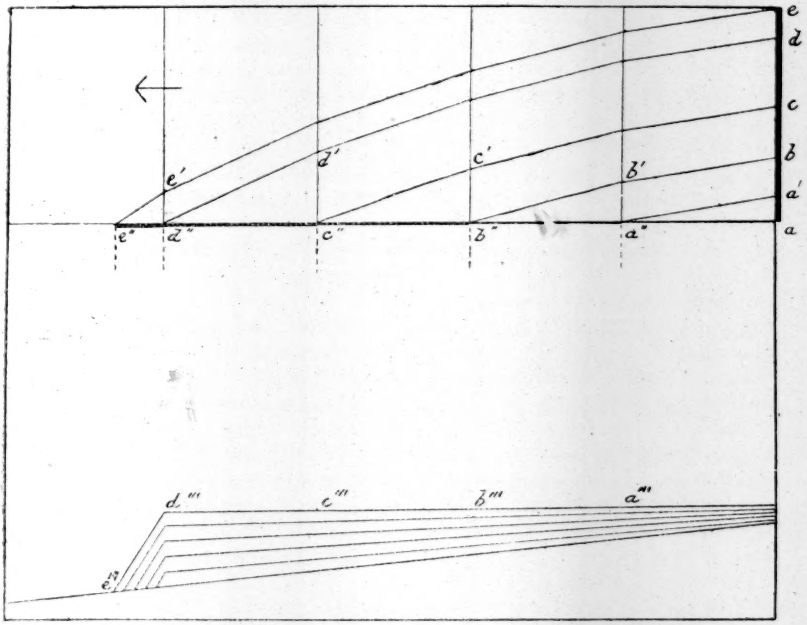


FIG. 2.—THE DISTRIBUTION ON THE SEA-BOTTOM OF A VERTICAL SHEET OF UNIFORM SEDIMENT.

a–*e*, the vertical sheet; *b*–*b'*–*b''* etc., the paths of particles; *a'''*-*e'''*, the deposit built up by successive sheets.

We must now see whether and how far this result may be modified by other causes. The rising of fresh water over salt will increase the rate of deposition, since the bottom of the current, instead of being horizontal, will curve upwards and so cut more lines of flow. The mixing of sea-water will have the same effect, as the resistance to sinking is known to be less in salt water than in fresh. Evaporation will have little effect, because the detritus will soon leave the surface. But all these causes increase in efficiency with time, and thus will accentuate the thickening of the deposit with increase of distance from the source of supply. On the other hand, the greater velocity of the stream in its centre would diminish the thickening; but this, when the sea is reached, is transformed into a special peculiarity, as will be seen further on.

The most important modification is the following. If a mass of water in motion is retarded in the direction of its flow it must

compensate this by spreading out transversely, so that its volume may remain the same. In the present case the current will spread out principally in a lateral direction, so that the sediment *contained in* any given volume of the current falls over a nearly constant area, and the deposit from that volume will be of equal depth throughout. This might seem at first to destroy the foregoing argument, but the thickening therein referred to is produced by the more rapid fall of the sediment in the higher layers *into* this volume, so that the wider lateral spread of the deposit is an *additional* effect. The constant widening of the current will deflect its margin to the right and left, and the flow-lines will form spirals on each side of the main axis, and there deposit some of the detritus they may carry.

And this will have a curious result. The thicker deposits from the slower moving water at the sides of the current will be laid down adjacent to the thinner ones from the faster moving water in the main stream. Thus there will be formed an apparent depression of the sea-bed below the course of the current, though the latter has never touched it. This will be marked by the higher contour-lines bending towards the source of the current. On the other hand, the detritus is carried farther out to sea in a straight direction before deposition, and the lower contour-lines will bend away from the source.

Such, then, is the original form of a single deposit from a current which starts with a given velocity and contains detritus of one rate of sinking. It is thinnest near the source of supply and gradually thickens to a maximum, until it ends seawards with a rapid slope; it expands at the sides with a curved boundary, convex seawards; and it has a depression opposite the source on its proximal, and a prominence on its distal side.

The total result from a current which varies in its velocity and contents will be obtained by superimposing all the wedges thus produced. If the variation be great the shorter wedges, corresponding to the most rapidly sinking detritus, may overbalance the thin ends of the wedges of finer detritus and make the *total* deposit thickest near the shore; but when the physical conditions remain constant for a long period and the current brings uniformly fine detritus, all the maxima will be added together and make the seaward end of the deposit much thicker than the shoreward (see Fig. 2).

The action of tidal and wind currents will modify these results. The motion of such currents may be resolved into two components, perpendicular and parallel to the shore respectively. The former, mostly in connection with the tides, have as detritus carriers a balance outwards, since the sea is essentially a denuding agent on the shore; they may therefore be included in the currents already dealt with. The latter will tend to destroy the details of higher contours, such as the bending shorewards opposite the source of an outward current; also to elongate the original deposits throughout at the expense of their thickness, and so join up the deposits from adjacent outward currents and make the line of greatest thickness a continuous one. Their action, however, is necessarily limited by

the depth to which they reach, which, except in the case of ocean currents, is said to be not greater than 100 fathoms. Down to this depth, therefore, the deposits from the suspended material carried by rivers are liable to be supplemented by the contributions made by the waves on the shore, and the contour-line of 100 fathoms will thus be accentuated.[1] This is the 'mud-line' of Dr. Murray, or the most common limit of terrigenous deposits to which the lightest particles—those of organic origin—are carried and form a feeding-ground for fishes, etc.

From this investigation it appears (1) that when a deposit consists of pretty uniform material of fine grain it is likely to end at the part most remote from its source in a steep slope seawards, and that its thickness there is unlimited except by the depth of the sea on which it is formed; (2) that at a greater or less distance from every shore there is likely to be found a narrow zone across which there is sudden fall in the sea-bottom, in which the contour-lines will be crowded together, but from which they may diverge locally opposite the mouth of any muddy river, a higher one towards it and a lower one away from it, and this zone is liable to be specially narrowed and thus accentuated when it occurs at a depth of about 100 fathoms; and (3) that both these results are due to the wedge-shaped form of the original sedimentary deposits in the sea.

Before proceeding to compare these results with nature, some account must be given of the relations of limestones to the deposits already dealt with. Limestone for the most part is introduced into the sea in the form of calcareous salts in solution; it does not usually take a sedimentary form until it has passed through some organism, and will therefore accumulate most where organisms such as precipitate the salts are most abundant. For such organisms to abound it is certainly necessary that there should be (1) abundance of calcareous salts supplied, (2) abundance of oxygen to induce activity, and probably also (3) freedom from mud. For the first condition, nearness to the shore, the source of such salts, is necessary; for the second, nearness to the air, whence the oxygen must be obtained; but for the third, or least certainly necessary one, remoteness from the sources of terrigenous deposits.

Since the discovery of pure Globigerina ooze at abysmal depths, it has been assumed that the third condition outweighs the other two and that limestone is an indication of deep water. Any such assumption is inadmissible, if for no other reason than this, that the Globigerinæ which live on the surface and sink to the bottom when dead are protected from all detrition; they are, therefore, extremely abundant in the ooze; but in the purest chalk the greater bulk is detrital, and must be washed away before the Foraminifera can even be looked for. Globigerina ooze, therefore, throws no light on the relation of limestone to depth. We must start again *ab initio*. There is not at present sufficient information available to enable us

[1] See N. M. Fenneman, Journ. Geol. Chicago, vol. x, pp. 1–32.

to say in what proportions each zone of depth contributes to the production of limestone by the organisms inhabiting it, because we cannot state the average number of the individuals in a given area which make calcareous hard parts, nor the weight of each hard part produced; but we can get some idea of the probable position of the maximum (on the principle that the more individuals there are struggling for existence, the more species will result) by availing ourselves of the results of the *Challenger* Expedition concerning the number of species met with in various zones of depth, as shown in the following table:—

Table showing the number of species of Calciferous Organisms in various zones of depth in the sea.

Range of depth in fathoms.	Calcareous sponges.	Corals.	Crinoids.	Echinoderms.	Lamelli-branchs.	Gasteropods.	Bryozoans.	Brachiopods.	Percentage of the whole.
0–100	29	313	51	79	319	686	224	14	56·3
100–500	8	52	34	53	134	381	124	18	26·4
500–1000	...	26	37	21	21	48	49	2	6·7
1000–1500	...	9	8	18	34	81	7	5	5·3
1500–2000	...	4	9	20	22	20	24	4	3·4
2000–2500	...	3	1	7	5	6	10	3	1·1
2500–	...	1	1	5	12	3	...	1	·7

It is here seen that 82·7 per cent. of the calciferous species occur in the uppermost 500 fathoms, and from the rapid rate of increase probably 80 per cent. in the uppermost 300 fathoms. Add to this that calcareous algæ abound with corals, and also without them, in the highest zone, and that, according to Pourtales, a bank made of Globigerinæ occurs in 100 fathom water off the coast of Florida, and we may feel confident that (possibly with a few exceptions) limestones containing an abundance of any of the above-named organisms cannot have been formed at a depth greater than 300 or 400 fathoms.

Thus the first two conditions for the flourishing of calciferous organisms are found to practically prevail, and the third must be satisfied in some other way than by remoteness from the shore, probably by the absence of mud-bearing streams in their neighbourhood.

Furthermore, it may be noted that the fauna of the deep sea is remarkable for its constancy, but the faunas of shallow water and of limestones are remarkable for their variation from spot to spot. Limestones are also largely detrital, not merely made of comminuted parts, but of impalpable calcareous mud—as in the Lias, the Chalk, and most marbles—and this detrition must have occurred in the zone of detrition, usually limited, as noted above, by the 100 fathom line.

(*To be continued.*)

IV.—The Blown Sands and Associated Deposits of Towan Head, near Newquay, Cornwall.

By A. Santer Kennard and S. Hazzledine Warren, F.G.S.

[*Note.*—The former author is responsible for the determination of the species and information relating to them; the latter author, for the field notes and other parts of the paper.]

Introduction.

At Towan Head and in the cliffs of Fistral Bay, near Newquay, there is seen, at a few feet above high-water mark, the remains of the Pleistocene Raised Beach. This consists of pebbly beds associated with ancient blown sands, sometimes of considerable thickness. Above this series of deposits comes the Head or Rubble Drift, formed during a greater elevation of the land.[1] These beds have been fully described by many authors—De la Beche,[2] W. A. E. Ussher,[3] Sir Joseph Prestwich,[4] and others. While capping the Head and Raised Beach, and on the top of the cliff, there is a series of more recent Æolian sandy beds.

Inland from Fistral Bay the dunes of recent blown sand cover a considerable area, but these are not discussed in the present paper. Attention is here directed to the superficial deposits of Towan Head. The dunes which cover the surface at Fistral Bay are quite recent accumulations, and are, in fact, still in process of formation, as the westerly winds from the Atlantic blow up the sand left dry upon the present beach. The recent dunes extend to Towan Head; but there are other sands, beneath them in stratigraphical position, yet still capping the Head, which are of greater antiquity, and present certain points of interest.

Mr. W. A. E. Ussher[5] gives the following section of the cliff toward the north end of Fistral Bay, near Towan Head:—

	feet.
Recent blown sand	3
Sandy soil with angular fragments of slate	2
[Head] Buff loam with angular stones and boulders	2
[Pleistocene blown sand of the Raised Beach] Buff sand	1
[Raised Beach] Coarse and fine gravel of quartz, dark grey grit, slate, and occasionally flint	4

The 'sandy soil' immediately above the Head is a representative of the beds chiefly dealt with here.

On the east side of the promontory of Towan Head, and close to the lifeboat house, there is a quarry in the cliff which exposes a section of these beds. At this spot the deposit consists of sand about four feet in thickness, containing many land shells, together

[1] R. A. C. Godwin-Austen: Quart. Journ. Geol. Soc., 1850, vol. vi, p. 94; 1851, vol. vii, pp. 121–126.

[2] H. T. de la Beche: "Report on the Geology of Cornwall," etc., 1839, p. 426, etc.

[3] W. A. E. Ussher, "The Post-Tertiary Geology of Cornwall": Geol. Mag., 1879, Dec. II, Vol. VI, pp. 206–207.

[4] J. Prestwich: Quart. Journ. Geol. Soc., 1892, vol. xlviii, pp. 281–282.

[5] Geol. Mag., 1879, p. 206.

with a smaller number of marine forms, including a layer of *Mytili* about the middle of the bed. This was erroneously referred to the Pleistocene Raised Beach in a former paper.[1]

The level of the Pleistocene Raised Beach varies somewhat, according to its thickness, and the irregularity of the rock surface on which it rests; but its base is generally at from two to ten feet above high-water mark. The shelly sand at the quarry, on the other hand, caps the top of a cliff about thirty feet or more in height. And, what is even more conclusive, it is a part of the superficial blown sands of the headland which overlie the Head, whereas the Pleistocene blown sands always underlie the Head. The general character of the deposit is that of the Holocene, and not that of the Pleistocene sands. And, as will be seen in the sequel, various remains of human occupation, such as pottery and kitchen-middens, are found in the same beds.

The layers of *Mytili* and occasionally other marine shells, which appear, at first sight, to indicate a salt-water origin, such as a lagoon (as suggested in the paper referred to), may be seen to be quite characteristic of the blown sands. They occur, not only in the cliff sections at Towan Head, but further inland, and at greater elevations above the sea, and in the most unquestionable dunes of blown sand, full of land shells. This occurrence of layers of marine shells (*Mytili*, etc.), often fragmentary, but sometimes perfect, in dunes of blown sand, is a well-known phenomenon of wind transport, and has been noticed by previous observers.

It seems possible, especially in view of the kitchen-midden presently to be described, that many of the marine shells from these sands, other than the layers of *Mytili*—shells which the wind could not so easily move—were carried up from the beach by man and dropped on the then surface of the ground.

The Table of Fauna.

In the accompanying Table the number of individuals of each species actually collected and determined is given in order to show their relative abundance in each bed dealt with. It must be stated, however, that in several cases the commonest forms were not all collected. This was especially the case with *Mytilus edulis*, which is far more abundant relatively to the other marine forms than appears in the table. The beds in which the mollusca were found are described under the details of the sections. They are placed in the table, as far as possible, in the order of their stratigraphical succession, though the letters over the columns run in the order in which they are described.

It will be noticed that we have divided the mollusca into four groups: Marine, Woodland, Sand Dune, and a group which inhabits both the last situations. The marine shells, as already suggested, no doubt owe their occurrence either to the wind, the hand of man, or perhaps the gulls. The term woodland, which is applied to the

[1] A. Santer Kennard & B. B. Woodward: Proc. Geol. Assoc., 1901, vol. xvii, p. 247.

TABLE SHOWING THE FAUNA OF THE BLOWN SANDS AND ASSOCIATED DEPOSITS OF TOWAN HEAD.

Habitat.	Species.	Late Pleistocene or early Holocene.		Holocene. Æolian Sands capping the Head.								Recent Sand Dunes.	Various Situations. Top of Head and Holocene Sand mixed.
				Lower part of Sands.				Upper part of Sands.					
		D	I	C	J	F	H	A	B	E	G	K	
Sand Dunes.	*Helicella virgata* (Da Costa)	...	...	1	...	...	...	7	17	17	121	1	78
	,, *itala* (Linn.)	...	...	1	10	1	111	5	6	208	69	12	281
	,, *barbara* (Linn.)	...	...	3	5	...	55	10	6	16	86	2	131
	Pupa muscorum (Linn.)	...	...	...	2	1	14	...	...	...	3	1	18
Woodland (chiefly) and Sand Dunes.	*Vallonia pulchella* (Müll.)	...	1	...	...	3	1	...	...	2	...	...	11
	Helix aspersa, Müll.	...	...	...	...	...	...	...	...	...	1	...	3
	,, *nemoralis*, Linn.	16	24	1	2	4	4	...	...	...	...	...	35
	Cochlicopa lubrica (Müll.)	...	1	...	...	1	3	...	...	3	3	...	8
Woodland.	*Pyramidula rotundata* (Müll.)	1	9	...	...	...	...	...	...	...	...	...	1
	Vitrea cellaria (Müll.)	...	1	...	...	...	...	...	...	...	...	...	1
	,, *nitidula* (Drap.)	1	5	...	...	...	...	...	...	...	...	...	2
	Arion ater, Linn.	...	3	...	...	...	3						
	Hygromia granulata (Alder)	...	...	...	...	...	...	...	...	...	...	...	3
	Clausilia laminata, Mont.	...	...	...	...	...	...	...	...	...	...	...	1
	,, *bidentata*, Ström.	...	2										
	Helix hortensis, Müll.	34	6	...	1	...	...	...	...	...	...	...	4
	Pomatias reflexus (Linn.)	...	...	...	1	...	7	...	...	...	...	...	1
Marine.	*Mytilus edulis*, Linn.	...	...	1	...	42	12	...	2	...	...	6	8
	Glycymeris glycymeris (Linn.)	...	...	...	...	1	...	...	...	...	...	...	2
	Patella vulgata, Linn.	...	...	1	...	15	...	...	...	...	...	...	1
	Purpura lapillus (Linn.)	...	...	...	...	3	1	...	...	2	...	...	2
	Littorina obtusata (Linn.)	...	...	...	3	...	...	...	...	...	...	...	3

next group, is a comprehensive one, and does not necessarily imply a forest growth. The woodland forms all require shade, moisture, and a growth of herbage; they could not exist on the sand dunes at present. The sand dune group includes those species which live there at the present day, and whose natural habitat it is; whilst the intermediate group comprises those species which can accommodate themselves to the sand dunes, though their true habitat is the same as that of the woodland group.

On examining the table it will be noted that in the lowest beds, viz. the top of the Head, the woodland fauna is alone represented, the true sand dune forms being absent. As we gradually go higher the woodland forms die out, and they are replaced by the sand dune group. It may therefore be inferred that the change in the conditions was not a sudden one, but gradual, and one operating over some considerable time.

A similar phenomenon is seen at Harlyn Bay, where in the Neolithic layer a woodland fauna is represented, which was subsequently driven out by the blown sands.

It is therefore evident that, at the time this woodland fauna lived on the north coast of Cornwall, the sea must have been at some considerable distance from the present shore.

Details of the Sections.

Taking now the sections seen on the cliffs on the west side of Towan Head, and beginning at a point a little north of the lifeboat house and working southward, the first point noticed was on the northern side of a cutting that leads to the beach. Here there is seen a very rubbly surface soil, beneath which there is about 2 feet to 2 ft. 6 in. of rubbly sand, underlaid with Head; while below, among the rocks of the shore, may be seen remains of the consolidated blown sands of the Raised Beach Series. In the rubbly sand, and at a depth of about eighteen inches from the surface, a fragment of pottery was found *in situ*. It is of the coarse, hand-made type that is especially characteristic of the Neolithic period, though whether it may belong to that period or not one cannot state with certainty. For, though characteristic of Neolithic times, this kind of pottery continued in use to a later date when better kinds were also made. At this spot, and at the same depth as the pottery, a few shells were collected. The list is placed in column A of the table of fauna. In the same bed, but a short distance further to the south, those given in column B were found. In the bottom of the sand, just above the Head, and immediately below where the pottery was found, there were those given in column C.

In the top of the Head, a few yards further to the south (on the other side of the cutting that leads to the beach), shells were very abundant; those that were collected are shown in column D. These were the lowest in stratigraphical position of any shells that were found. Many of them were firmly attached to the angular fragments of rock which form so large a part of the Head.

On the top of the Head, and beneath three or four feet of blown

sand, at some little distance to the south of the lifeboat house, a flint was found that shows some signs of having been chipped. It may be quite accidental, and is certainly too indefinite to rank as evidence, but since flint is scarce and kitchen-middens occur at no great distance and on nearly the same horizon, and there is also the pottery already mentioned, it seems worth while to mention it.

Still further to the south, at the extremity of a miniature point to the north-north-west of the Headland Hotel, the cliff is capped by about six feet of loamy sand, with the usual layers of *Mytili*; while at the bottom of the sand, and separated from the Devonian slates by a very thin deposit of Head, there are two kitchen-middens. These are only a few inches in thickness, and they are separated from each other by a layer of loamy sand. They are largely made up of shells of *Mytili*, though *Patellæ* are also common, together with charred wood and stones showing the action of fire; there is also a great amount of black material in their composition. A number of shells were collected from the sands above the kitchen-midden; the list is given in column E. Only a few land shells were seen in the kitchen-midden; the list is in column F.

At the next small point in the cliffs, on the opposite side of a miniature cove, the following section was measured:—

	feet.
Holocene blown sand, with a layer of *Mytili* at about five feet from the surface	9
Head: angular rock débris and loam	5
Pleistocene blown sand, partially consolidated, belonging to the Raised Beach Series	8

The Pleistocene blown sand and Head are rudely interstratified together at their junction. At the point where the section was taken, the rocks of the shore are high, and the old Blown Sand of the Raised Beach is eight feet in thickness; but in the little coves where the rocks are lower, the Raised Beach Series descends correspondingly to within a few feet of high-water mark, and thus indicates a greater thickness. At the lower points there are frequently beds of pebbles at its base, though these are not so strongly developed as in Fistral Bay.[1] In the upper part of the sand, above the layer of *Mytili*, and at from two to three feet from the surface, the species shown in column G were collected. At from five to six feet from the surface, and in and below the layer of *Mytili*, were those given in column H.

Following the cliffs further to the south, and just west of the Headland Hotel, it is to be noted that the layer of *Mytili* gradually rises up to the surface, while the sands between that layer and the Head thicken proportionally. This, though much flattened by time, is evidently an ancient dune. At a little distance in this direction, and near the next small cove, another kitchen-midden is seen in the sand at about five feet from the surface. This is in every way similar to those already described, but, so far as can be seen,

[1] They were probably situated further out to sea than the pebble beds of the bay, and so have been destroyed.

it is of smaller extent. At this spot there is a particularly clear section of the Holocene blown sands and upper part of the Head. The latter is seen to gradually lose its distinctive character towards the top, and to pass almost insensibly into the blown sand above. Along the line of junction, through a thickness of about nine inches, land shells were fairly abundant; those collected are given in column I.

The bed in which these (column I) occurred was a loamy sand, intermediate alike in position and character between the Head and the blown sand above. They are consequently on a somewhat higher horizon than those in column D. It is worthy of note that the proportion of pure woodland forms is also less, while those that can accommodate themselves to sand dunes also are more abundant.

A few feet above this bed, in the lower part of the sand, and on about the same level as the kitchen-midden, a few shells were collected; they are shown in column J.

To the east of the Headland Hotel there are well characterized dunes of recent blown sand. These are almost the last stragglers in this direction of the great dunes of Fistral Bay. A small section in one of these showed one of the familiar layers of *Mytili*; a few of these were collected, together with some of the characteristic sand-dune forms; they are given in column K.

In the last column of the Table of Fauna is a list of species from various situations at Towan Head. The pure woodland and chiefly woodland forms were mostly taken along the line of junction between the Head and the Holocene blown sand, but in places where the sections were not quite clear. This list includes two species not recorded elsewhere in the Table.

With more prolonged work upon these beds the list of species could undoubtedly be extended, but the conclusions based upon the nature of the dominant species would not thereby be affected.

Age and Mode of Formation of the Deposits.

With regard to the precise age of the sands immediately above the Head there is no definite evidence. So much as is available has already been mentioned—the pottery (column A of the Table), which is very probably Neolithic, the flint, which may possibly be of the same age, and the kitchen-middens. Neither is there any evidence at present as to the age of the kitchen-middens, and opportunities for a thorough investigation were wanting. Kitchen-middens have previously been found in the neighbourhood of Newquay, and there are the important discoveries at Constantine and at Harlyn Bay,[1] which are sufficient to stimulate further search on the archæological side.

In reference to the mode of formation of these deposits, one notices that in the passage from Pleistocene blown sand to Head, and again from Head to Holocene blown sand, there is, as it were,

[1] C. Spence Bate: Trans. Devon Assoc., 1864, vol. i, pp. 138–139; Report Brit. Assoc., 1864, p. 88. The Rev. R. Ashington Bullen: "Harlyn Bay and the Discoveries of its Prehistoric Remains"; London, 1902.

a struggle to hold the field between the accumulation of sea sand driven up by the wind and the accumulation of rock débris and loam under atmospheric erosion. In the cliff sections to the westward of the Headland Hotel the Pleistocene blown sand and the Head are rudely interstratified together at their junction, while at a short distance away the Head is seen to pass almost insensibly upward through loamy sand into the Holocene blown sand above. The former case is evidently due to the fluctuation in the dominance of the one mode of accumulation or the other, during a gradual change in conditions, as already suggested. There can be little doubt but that this was caused by a gradual elevation of the land, and consequent removal from the source of supply of the sand, together with increase in erosion of the surface; and when, after the Head, the Holocene blown sands became dominant, to an almost equivalent depression.

One naturally speaks of these changes in the relative level of land and sea in terms which refer to the elevation and depression of the land. Recent researches have shown, however, that the surface of the sea is by no means the uniform level that we have been wont to imagine; and that these changes may equally well be due to local fluctuations in its level. But for purposes such as that of the present paper, one can be content to leave the question unsolved.

V.—Notes on Fossil and Recent Shells obtained on a visit to Cornwall.

By J. P. Johnson.

THE following notes were made during the little time I was able to devote to leisure while staying at Camborne in order to study the methods there employed of mining and dressing the tin-bearing rock. They therefore deal only with places within easy reach of that town.

The whole of this district is made up of extremely ancient rocks, of which I must content myself with saying that they afford a boundless field for those interested in the variation and alteration of granite, in the killas through which it rises, and in the granite-porphyry and other dykes with which these are traversed; or for those seeking to unravel the many problems connected with the mode of occurrence of the tin and copper lodes. Here and there, resting on these old rocks, are scattered patches of comparatively recent deposits, none of which date back to before the Neogene era.

The most interesting of these is certainly the fossiliferous Pliocene clay at St. Erth. All information concerning it was summarized by Clement Reid[1] in 1890, and increased in 1898 by Alfred Bell,[2] who also figured some of the more noteworthy shells. The deposit is of very limited extent, and is situated in the valley, then probably a strait, which connects Mounts Bay and St. Ives Bay. The exposures, which I was enabled to examine through the courtesy

1 "Pliocene Deposits of Britain": Mem. Geol. Surv., London, 1890.

2 "On the Pliocene Shell-beds at St. Erth": Trans. Roy. Geol. Soc. Cornwall, 1898, vol. xii.

of the Rev. C. R. D. Carter, are all very small, the deepest being as follows :—

	feet.
Coarse sand	7
Brown and mottled clay, passing into blue ...	3

The shells occur in the lower (blue) portion of the clay, and, as a rule, are not by any means common, though here and there, in sandy patches, those of *Bittium reticulatum* occur in great quantity. Next in order of abundance are those of *Nassa semireticosa*, two or three being met with in every cubic foot of clay. The following list shows the number I obtained of each species and the result of two days' digging. Those indicated by an asterisk are figured by Alfred Bell in the paper already cited ; the others are figured by S. V. Wood in the volumes of the Palæontographical Society. The specific names used by these two authors are here employed, but prior ones are given in parentheses. Those species of which I only obtained fragments are indicated by the letter F.

I would here remark that I am much indebted to Mr. R. B. Newton for his kindness in enabling me to compare the specimens in the Geological Department of the British Museum (Natural History).

1. *Columbella erythrostoma.*
7. *Ringicula ovata.**
30. *Nassa semireticosa** (? = *serrata*, Br.).
2. *Nassa recticosta.**
1. ,, *granifera.*
2. ,, *mutabilis.**
6. *Turritella incrassata* (=*triplicata*, Br.).
1. *Pyramidella lævisecula.*
1. *Odostomia conoidea.*
300. *Bittium reticulatum.*
1. *Natica proxima* (=*sordida*, Phil.).
1. ,, *catena.*
2. *Calyptræa chinensis.*
1. *Paludestrina subumbilicata* = *ventrosa*, Mont.
4. *Rissoa ovalis.**
2. ,, *Montagui.**
1. ,, n.sp. ?
1. ,, sp. ?
1. *Calliostoma*, sp. ?
1. *Montacuta bidentata.*
2. *Lucina borealis.*
F. *Pecten*, sp. ?
F. *Ostrea*, sp. ?
F. *Nucula*, sp. ?

I also found one or two Foraminifera.

South of Godrevy lighthouse, resting on a terrace of killas, is a Pleistocene beach. It is made up of pebbles of killas, granite, and quartz, and is overlain by a variable thickness of rubble-drift consisting of similar materials embedded in loam. I did not succeed in finding any organic remains in either of them, but my friend Mr. F. A. Ginever has procured a couple of shells of *Patella vulgata* from the ancient beach.

On the top of the cliffs, but lying back some distance from the edge, are extensive Holocene sand-hills or 'towans.' These have long ceased to move, being sealed up under a layer of turf. They contain numerous shells of *Helicella itala*, *H. virgata*, and *H. barbara*, whilst I also found one of *H. caperata*.

On the further side of the sand-covered gap, where the red stream empties itself into the sea, are Gwithian Towans. From a section in one of them, at a depth of ten feet, I obtained an assemblage of molluscan remains similar to that recorded above, as well as a few shells of *Helix aspersa* and one each of *Cochlicopa lubrica* and *Vallonia pulchella*.

During a brief visit to Hayle I came across an interesting deposit overlooking the mouth of the river from the right bank. It is exposed at the top of a quarry (marked "gravel pit" on the old six inch map), and is as follows :—

	feet.
(*a*) Clean sand with land shells	2
(*b*) Dirty compact sand with *Helicella virgata* and occasional broken mussel and cockle shells	1½
(*c*) Clean sand with *Helicella barbara* and cockle-shells	1
(*d*) Layer of broken mussel-shells.	
(*e*) Pieces of killas in clay (rubble-drift), the top half foot sandy with fragments of mussel-shells	5
(*f*) Killas.	

The most interesting feature is, of course, the layer of broken mussel-shells, which is clearly the remains of an old kitchen-midden. From it I obtained a neat little flint flake of the arrow-head type, the tip of which had been broken off. From bed (*b*), which also bears evidence of the presence of man, I obtained a shell of ***Helix aspersa*** and a tooth which my friend Hinton has identified as belonging to sheep.

While speaking of flint flakes I may mention that I picked one up near Godrevy and another on Carn Brea. At the latter place there are a number of hut-circles, from the interior of which numerous arrow-heads, scrapers, and other implements have been exhumed.

From the adjoining Riviere Towans I obtained shells of the following molluscs :—

Vitrea nitidula (Drap.).
Pyramidula rotundata (Müll.).
Hygromia granulata (Ald.).
Helicella itala (L.).
,, *caperata* (Mont.).
,, *virgata* (Da C.).
,, *barbara* (L.).
Helix aspersa, Müll.
,, *nemoralis*, L.
Cochlicopa lubrica, Müll.
Clausilia bidentata, Ström.
Carychium minimum, Müll.
Patella vulgata, L.

With the exception of ***Carychium minimum, Cochlicopa lubrica, Clausilia bidentata,*** and ***Hygromia granulata,*** they were all common. One of the shells of ***Helicella barbara*** is nearly 19 mm. in length.

I made one or two expeditions in search of living non-marine molluscs, and the following list of the species I obtained may be of service to compare with that of the fossil ones :—

Testacella maugei, Fér.
Limax maximus, L.
Agriolimax agrestis (L.).
Amalia Sowerbyi (Fér.).
Vitrina pellucida (Müll.).
Vitrea cellaria (Müll.).
,, *lucida* (Drap.).
,, *nitidula* (Drap.).
,, *excavata* (Bean).
Euconulus fulva (Müll.).
Arion ater (L.).
Pyramidula rotundata (Müll.).
Helicella itala (L.).
,, *caperata* (Mont.).
,, *virgata* (Da C.).
Helicella barbara (L.).
Hygromia granulata (Ald.).
,, *hispida* (L.).
,, *revelata* (Fér.).
,, *rufescens* (Penn.).
Acanthinula aculeata (Müll.).
Vallonia pulchella (Müll.).
Helix aspersa, Müll.
,, *nemoralis*, L.
Cochlicopa lubrica (Müll.).
Pupa cylindracea (Da C.).
Clausilia bidentata (Ström.).
Carychium minimum, Müll.
Ancylus fluviatilis, Müll.

The most interesting of these is certainly the rare *Hygromia revelata* (Fér.), which I came across at St. Michael's Mount. I found it high up on small ledges of rock.

From the same locality I obtained the two shells of *Testacella maugei*. One of them is unusually large, measuring 18 mm. from the tip of the vestigial spire to the anterior margin. This discovery considerably extends the known range of this species in Britain.

I obtained only one specimen of *Vitrea lucida*. In the woods among the dead leaves I found *Vitrea excavata* in abundance, also, among the ivy, the pretty little *Acanthinula aculeata*, and, in hollows, *Vitrea fulva*. In the hedgerows, and particularly among nettles, I obtained *Hygromia granulata*, *H. hispida*, and *H. rufescens*; and on walls, *Clausilia bidentata* and *Pupa cylindracea*. On the sand-hills along the coast *Helicella barbara* occurred in myriads, together with *H. virgata*, *H. itala*, and *H. caperata*; it is noteworthy on account of the abnormal shape of the shell and its limited distribution in this country.

Ancylus fluviatilis is the only aquatic mollusc I succeeded in finding. It was common on the stone-strewn bed of the streams.

VI.—On two Trilobites from the Devonian Slates of Cornwall, obtained by Walter Barratt, Esq.

By Henry Woodward, LL.D., F.R.S., F.G.S.

HAVING been favoured by Mr. Walter Barratt, of Sunnybank, Newquay, Cornwall, with the opportunity of examining two Trilobites from the Devonian slate-rock—(1) from a cove near Trevose Head, (2) from the shore of the mainland opposite Trescore Island, Porthcothan, Cornwall,—I gladly avail myself of his permission to publish a note thereon.

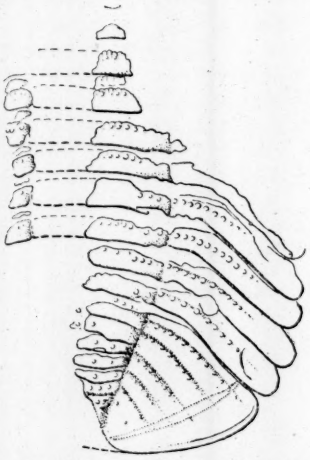


Fig. 1.—A new Devonian Trilobite from Cornwall: *Homalonotus Barratti*, sp. nov. Two-thirds nat. size. Devonian Slates: Trevose, Porthcothan, Cornwall.

Mr. Howard Fox, F.G.S., of Falmouth, has lately directed attention to some recent discoveries of obscure organisms from the same Devonian rocks at a meeting of the Royal Geological Society of Cornwall (November, 1899), and published afterwards in the Geological Magazine (April, 1900, Dec. IV, Vol. VII, pp. 145–152, Pl. VII); he describes and figures some of the most noteworthy of these, giving also a list of localities where found.

Mr. Fox mentions the rocks both north and south of the River Camel, in Padstow Harbour, where simple cup-corals and fragmentary crinoidal remains have been obtained; he also records that at Trevone fossils occur at several distinct horizons — *Pteraspis*, *Orthoceras*, *Bactrites*, *Goniatites*, *Euomphalus*, *Cardiola*, *Centronella*, *Phacops*, *Tentaculites*, *Styliola*, *Amplexus*, *Favosites*, and *Pachypora*. At West Newtrain Bay *Scaphiocrinus* and a Favosite coral were obtained. At Mother Ivey's Bay, *Tentaculites*, *Centronella*, *Hyolithes*, and crinoidal stems. Porthcothan Cove, south of Trevose Head, has yielded *Petraia*, *Pleurodictyum*, *Phacops*, sp., and obscurely shown examples of *Orthoceras* and *Goniatites*. Lower Butter Cove yields similar fossils to Porthcothan and Porth Mear. Bedruthan Steps—here *Steganodictyum* (= *Pteraspis*), *Orthoceras*, *Sphærocrinus*; some corals, *Pleurodictyum*, *Aulopora*?, *Petraia* occur, with *Pteroconus mirus*, etc. At Watergate or Tregurrian Bay and Beach, 2¼ miles north of St. Columb, Porth; also between Fowey and Polperro, the slates are found to be highly fossiliferous.

Homalonotus, König, 1825.

Homalonotus is a very characteristic form of Trilobite, and is easily distinguished from other genera, even from its nearest ally, *Calymene*.

The peculiar trilobation of the body-rings, so conspicuous in most genera, is very indistinct in *Homalonotus*, especially in the thoracic segments, although in some species it is better marked in the pygidium. The shape of the body is elongate, convex, with steep sides, and a very broad axis, scarcely distinguished from the pleuræ. There are thirteen body-rings, deeply grooved, and the fulcrum is close to the axis in most of the species. The head is triangular, with an obscure quadrate glabella slightly lobed, and a quadrate labrum; the surface of the body is scabrous, occasionally spinous. The pygidium is generally narrow and pointed, except in a few species which have a more rounded contour.

Of the twenty species recorded, by far the larger number are from the Silurian. The following are from the Devonian of Devon and Cornwall (and two are also exotic, namely, *H. Herscheli* and *H. Pradoanus*):—

Homalonotus armatus, Burm.		Devonian:	Cornwall.
,,	*Champernownei*, H. Woodw.	,,	Torquay.
,,	*elongatus*, Salter.	,,	S. Devon.
,,	*goniopygæus*, H. Woodw.	,,	Torquay.
,,	*Herscheli*, Murch.	,,	Devon and S. Africa.
,,	*Pradoanus*, De Vern.	,,	Spain.
,,	*Barratti*, H. Woodw.	,,	Cornwall.

The Devonian species of *Homalonotus* occur in Cornwall and Devon, and extend into Germany and Spain. One species is met with as far off as South Africa (*H. Herscheli*).

All the Devonian Trilobites appear to be referable to Mr. Salter's section of Homalonoti *with spines*, which he named *Burmeisteria*: this division includes all those species having the body elongate, convex; head triangular; eyes approximate on gibbous cheeks; glabella distinct, lobeless, sinuous; thorax slightly lobed and spinous, as is also the many-ribbed, pointed tail. He takes for his type *H. Herscheli*, from the Devonian.

Mr. Salter's *Homalonotus elongatus* is founded upon a *tail only*, remarkable, even in this elongated genus, for its length and shape. This form is very strongly trilobed, and appears to have had four pairs of spines along its median axis and two pairs upon the lateral portion. (See Salter: Mon. Pal. Soc., 1865, pt. ii, p. 122, pl. x, figs. 1, 2.)

Homalonotus Champernownei has little or no signs of trilobation, and is rather larger than the celebrated *H. delphinocephalus* from the Wenlock Limestone of Dudley; it has thirteen free moveable thoracic segments with broadly expanded pleuræ, each rib armed with a pair of spines placed about one inch apart; the head also had three pairs of spines placed on the lateral portion, and three along the medial line; there is no evidence of cheek-spines; the pygidium is imperfect. (See Geol. Mag., 1881, Dec. II, Vol. VIII, p. 489, Pl. XIII.)

In Mr. Barratt's specimen from a cove in the Devonian slates of Trevose Head, Cornwall, we have only evidence of one side of the pygidium, five of the posterior free thoracic segments, and fragments of others. Assuming these to have been compressed longitudinally so as to make them appear disproportionately broad and short, they still have the characteristic deep falcate margins to the free segments and the six or seven well-marked coalesced segments to the pygidium seen in other species of this genus; but, though only a fragment, we notice that each segment, both in the free thoracic rings and in the coalesced segments of the tail, is marked by a single row of small rounded tubercles uniform in size, ten on each pleura and an uncertain number on the axis of the body; those on the coalesced segments of the tail diminishing in number backwards from ten to eight, to six, to four, to three. The ribs of the tail do not extend to the margin, but leave a smooth rounded border. It would be impossible to give a more detailed description of so mere a fragment, but the single row of extremely regular tubercles on each segment suffices to separate it from other Devonian or Silurian forms with which I am acquainted. The Figure, which is reduced to two-thirds natural size, serves to convey a correct idea of this interesting fragment.

So soon as attention is directed to the occurrence of Trilobites in these Devonian slates at Trevose, no doubt many more specimens will be found to reward the diligent seeker after organic remains. Dr. Arthur Smith Woodward, F.R.S., in his Catalogue of Fossil

Fishes, vol. ii, writes:—"Fragments of Pteraspidian shields, not sufficiently complete for precise determination, are met with in the Lower Devonian of Cornwall, and were originally described as fossil sponges by McCoy."[1]

Their fish-like character was first noted by Mr. C. W. Peach (Report Brit. Assoc., 1843 (1844), Trans. Sect., p. 56), who collected many specimens; they were subsequently assigned to *Pteraspis* by J. W. Salter (see Wyatt-Edgell, Geol. Mag., Vol. V (1868), p. 247), and finally named *Scaphaspis Cornubicus* by E. Ray Lankester & H. Woodward (Geol. Mag., Vol. V (1868), p. 248) and J. E. Lee, ibid. [2], Vol. IX (1882), p. 105, Pl. III, Figs. 2 and 3. Numerous fragments from Polperro are preserved in the Lee Collection in the British Museum, and larger specimens from Fowey.

These obscure fossils, first described as sponges by McCoy, were also referred to cuttle-fishes by Roemer (1855), under the name of *Archæoteuthis Dunensis* (*Palæontographica*, Dunker & von Meyer, vol. iv, p. 72, tab. xiii), now referred to *Scaphaspis Cornubicus*. The late Dr. S. P. Woodward (1856) called attention to the true ichthyic character of Roemer's supposed *Archæoteuthis* in his "Manual of the Mollusca" (p. 417).

Phacops, Emmrich, 1845.

Phacops latifrons (?), Bronn.

The specimen which I refer to this species is *only a fragment* of a small example from the mainland shore opposite Trescore Island, Porthcothan, Cornwall.

It is seen in profile; the head is *very obscure*, and is followed by *about* ten thoracic rings with rounded bevelled pleuræ; the line of the median axis is indicated on the one side preserved; the other side is wanting. Length of thoracic segments 15 mm., depth of same as half seen 15 mm.; length of pygidium 6 mm., depth of profile seen 9 mm.; there is a distinct raised and grooved border to the pygidium, but the furrows of the coalesced segments forming the tail-plate are worn away (by the sea?).

I have referred this example to *Ph. latifrons* ?, doubtfully (as the specimen is so imperfect), because it is a very common Devonian Trilobite and has been obtained at quite a number of localities in Devon and Cornwall. It is to be hoped that better specimens may shortly be met with by Mr. Barratt or other Cornish geologists.

Horizon.—Lower Devonian. Localities: Hope and Barton, South Devon; near Liskeard and Totnes, in slates with *Pleurodictyum problematicum*.

Upper Devonian.—Barnstaple, Croyde, Brushford, Pilton, etc., abundant. Foreign localities: Rhenish Prussia, Belgium, France, Russia; Andes, South America.

[1] F. McCoy: Ann. and Mag. Nat. Hist. [2], vol. viii (1851), p. 481, and Brit. Palæozoic Foss. (1851), pl. ii A, figs. 1–3.

VII.—Belemnites of the Faringdon 'Sponge-gravels.'

By G. W. Lamplugh, F.G.S.

DURING a preliminary traverse of the Lower Cretaceous outcrop in the Midlands last June, I visited Faringdon for the first time, and examined the famous sections in the 'Sponge-gravels.' My chief aim was to obtain some evidence by which the relative position of these beds in the Lower Cretaceous series might be determined. The greater part of the fauna was so anomalous and peculiar that it afforded little or no assistance towards this purpose, and the only common fossil which gave definite promise of service was the fragmentary *Belemnites*, which I found in unexpected abundance. It is true that I had previously noticed a few specimens among the Faringdon fossils in the Natural History Museum (from the Caleb Evans' Collection) and in other public collections, and had seen references to *Belemnites* in descriptions of the 'Sponge-gravels'; but I went with the impression that its occurrence was rare and exceptional, whereas I found that it could be collected plentifully from every pit, though always in a more or less worn and fragmentary condition, and generally encrusted with small oysters, serpulæ and polyzoa, and perforated by marine borers. The scant attention which the fossil has hitherto received is probably due to the prevalent opinion that it is derivative from the Jurassics, but this opinion is almost certainly erroneous, as I shall now try to show.

In the large number of specimens which I obtained only one species appears to be represented, and this species cannot, I think, be matched among Jurassic Belemnites. A careful comparison of the form with my large collection of Lower Cretaceous Belemnites from Speeton and Lincolnshire has satisfied me that all the specimens collected or seen by me may be referred to the species figured and described by Professor Pavlow ("Argiles de Speeton," pl. vii, figs. 13 and 14, and p. 88) as *Belemnites Speetonensis*. This species occurs abundantly in the 'zone of *Bel. Brunsvicensis*' at Speeton and in Lincolnshire, and is indeed probably an offshoot or extreme variety of the zonal species. In fragments of the thicker portion of the guard the Faringdon specimens might be mistaken for *Bel. lateralis*, which occupies a well-marked zone at or below the base of the Lower Cretaceous in the north-east of England; but when the pointed end is preserved, the tapering outline, depth and slight grooving strongly distinguish the species. The Speeton fossils are in a different state of preservation; but specimens of *Bel. Speetonensis* in my collection from the Tealby Limestone of Lincolnshire so closely resemble the best examples from Faringdon that if mixed without identifying marks they would be very difficult to separate.

I noticed a difference in the average size of specimens from different pits at Faringdon which I thought at first might be of import; but a simple explanation of this distribution soon presented itself. The Faringdon 'gravels' have clearly been heaped together as a current-swept bank on the old sea-floor; and materials of

different size and density have been rudely assorted by the currents, the heavier preponderating in one place, the lighter in another; and where the pebbles are largest, there also are the largest Belemnites found.

From the character of the deposit it has long been recognized that only a small proportion of its organisms can have actually lived where they occur. The case of the Belemnites is not therefore different from that of the majority of the fossils, except that, owing to their weight, brittleness and shape, they have suffered greater attrition than the shells during transport. The presence of numerous pebbles derived from older rocks, as large and larger than the Belemnites, does indeed show that there is no inherent impossibility in the view that these also might be derivative; but the determination of the fossils as representing only a single species, and moreover, one which is not of Jurassic age, is strong evidence against this view. It cannot, indeed, be proved that the specimens are *exactly* of the age of the deposit, but I think it is certain that they cannot be *much* older; and that at any rate they were lying on the sea-floor along with other organisms which were swept together to form the bank.

We will now consider what indication these Belemnites give as to the age of the 'Sponge-gravels.' *Bel. Speetonensis* at Speeton and in Lincolnshire occurs only in the 'zone of *Bel. Brunsvicensis*,' and therefore in beds comparatively high in the Lower Cretaceous Series. The uppermost portion of this zone contains *Amm.* (*Hoplites*) *Deshayesi* and other characteristic fossils of the Atherfield Clay and lowest part of the Lower Greensand of Kent and the Isle of Wight; and although the zonal Belemnite has not yet been observed to occur in these beds in the south of England, the correlation of the Atherfield Clay with the upper part of the 'zone of *Bel. Brunsvicensis*' of Speeton appears to be well established. Whether the Faringdon Belemnites are actually contemporaneous with or somewhat older than their matrix, the 'Sponge-gravels' cannot represent a lower horizon than the upper part of the 'zone of *Bel. Brunsvicensis*.'

In the Hythe Beds of Kent and at a corresponding horizon in the Isle of Wight there is occasionally found a form of *Belemnites* which is the same as a species occurring at Speeton,[1] above the 'zone of *Bel. Brunsvicensis*' and below the 'marls with *Bel. minimus*.' The nomenclature of this species has been greatly confused, and stands in need of careful elucidation; in some lists it appears as *Bel. jaculum* and as *Belemnitella plena*, from both of which, however, it is quite distinct; it is probably the form known on the Continent as *Bel. fusiformis*, Voltz. I did not find any trace of this species at Faringdon, and its apparent absence suggests that the 'Sponge-gravels' may be older than the beds containing this fossil in Kent and at Speeton, though its rarity anywhere in the south of England

[1] See my paper "On the Speeton Series in Yorkshire and Lincolnshire," Quart. Journ. Geol. Soc., vol. lii (1896), p. 181; and notes on the Hythe Beds in Annual Summary of Progress of Geol. Survey for 1897, p. 129.

should perhaps forbid us laying much stress on its absence in this particular locality.

On the evidence of the Faringdon *Belemnites*, then, we may conclude that the 'Sponge-gravels' are probably equivalent to the lowermost portion of the Lower Greensand Series of south-eastern England; and I am not aware of any facts adverse to this conclusion either in the other components of the fauna or in the stratigraphical position of the deposit. I hope hereafter to discuss the relations of the Faringdon Beds to other fossiliferous portions of the Lower Greensand of the Midland counties.

VIII.—Quartz Dykes near Foxdale, Isle of Man.[1]

By J. Lomas, A.R.C.S., F.G.S.

IN the neighbourhood of Foxdale, Isle of Man, and especially on Granite Mountain, the ground is strewn with numerous blocks of quartz. Many of them are of large size, 10 feet or more in diameter.

On the slopes of South Barrule similar blocks are found in great profusion, and they can be traced across the hills to the west coast. North of Foxdale other bands are found, some of which are inserted in the geological map. They lie principally in the altered slates of the Barrule Series, and have a general trend corresponding with the main axis of the island, from north-east to south-west. In places they are seen to be *in sitû*, and where the granite mass of Foxdale intervenes the general direction changes, and is principally tangential to the intrusion.

Numerous micro-granite dykes extend along the axis of the island in the same direction.

In an old quarry at Renshent on the north margin of the granite several quartz veins are seen to traverse the granite itself. They can be traced along the floor of the quarry and up the vertical face about 30 feet high.

One of these, about 3 feet in width, shows perfectly sharp margins when cutting through the granite, dips at 65° W., and strikes 10° E. of S. It consists mainly of quartz, some clear and some white and opaque, but on entering the granite it changes locally to a pegmatite. The pegmatite contains, in addition to the quartz, large felspars, some over 3 inches long, perfectly formed, and showing crystal faces, and mica in crystals over an inch in diameter. The granite outside the vein shows the normal features of the medium-grained Foxdale type.

Under the microscope the clear quartz of the vein is seen to consist of one crystal, all parts of the field extinguishing at the same angle. The white opaque parts behave optically in the same manner, but numerous bubbles containing liquid are contained, and these, no doubt, give rise to the opacity. The inclusions are mostly in lines, and sometimes take the form of negative crystals, the principal axes of which are parallel to the cross wires when extinction takes place.

[1] Read before the Liverpool Geological Society, November 11th, 1902.

A little to the east of the quarry is a larger quartz vein about 20 feet wide, which has been worked, and good exposures are visible. The quartz has exactly the same characters as that already described, and the vein can be traced as a feature and by occasional outcrops to Windy Common, above Cloughwilly, a distance of over a mile. Here several cuttings have recently been made, which show the large blocks on the surface to be *in sitû*. One of these has proved to be 30 feet wide; it cuts through altered slate containing numerous needles of epidote, and is accompanied on the east side by a micro-granite dyke.

Another cutting further to the west and almost on the summit of the knoll known as Granite Mountain, reveals a vein of quartz, 8 feet wide and dipping 65° E., contained in walls of much altered slate.

At Whallag, under South Barrule, 4 miles south-west of Renshent, the ground is strewn with quartz blocks which lie in great profusion on the moor. Across one of the larger masses a trench has been cut to prove its extent, and it is found to be *in sitû*, and forms part of the series of veins which traverse the slates.

A little gulley cut by a stream near the Farm Reasch reveals other quartz veins of smaller extent, and a small micro-granite dyke not shown on the geological map.

Dealing first with the Windy Common vein above Cloughwilly, in the cutting it is seen to consist of white opaque quartz with joints running transversely, forming horizontal columns. The joints are more numerous at the margins than in the middle, reminding us of similar features seen in basalt dykes. On the broken faces white mica is often found. Under the microscope it is seen to be indistinguishable from the quartz contained in the pegmatite. The liquid enclosures and negative crystals are perhaps more numerous, but all the quartz of the slide is orientated in the same direction, and extinction takes place in all parts at once. In this rock there is no sign of shearing.

The 8 ft. dyke on the summit of Granite Mountain differs only from the one just described in exhibiting traces of incipient shearing. There has been no displacement, but cracks divide the crystal into lenticular areas, leaving the whole in optical continuity. The lines of bubbles are quite independent of the cracks.

At Whallag almost exactly the same features occur, and fragments of altered slate up to 5 or 6 inches in diameter are sometimes included in the quartz.

Further to the south-west, and in the same general direction, the slates of the coast, as at Fleshwick Bay, contain quartz bands. They are folded and twisted with the slates, and often separated into lenticular bands. A slice from one of these bands shows under the microscope quartz of exactly the same character as those described, but shearing has gone on to such an extent that actual displacement has taken place.

Along the lines of movement a fine quartz mosaic has been formed, but the units which have moved are simple crystals.

Under crossed nicols the mosaic is seen to consist of areas of uniform extinction, and the included bubbles bear no relation to the lines of shear.

We are here forced to conclude that the parts have once been continuous, that the liquid inclusions are original features, and that they are portions of veins which have been disconnected by earth movements.

If the quartz, when traversing the granite, is of igneous origin, and the formation locally of a pegmatite is proof on this point, we cannot deny a similar origin to the quartz occurring as veins in physical continuity with that in the granite.

There is *a priori* no reason why quartz should not exist as an igneous rock. Given a magma with a limited amount of bases, combinations would go on until the silica had united with all the bases available, and then a residuum would be left which on consolidation would be pure quartz.

A comparison might be made of these veins with the Pfahl of Bohemia, where quartz occurs as veins through the granite and mica-schists, extending in unbroken sheets over a distance of 55 kilometers. Gümbel, however, has shown that the Pfahl is associated with displacement, and he regards the quartz as filling up cracks after faulting. In the Isle of Man, I am inclined to look upon the veins as true igneous dykes, running parallel to the micro-granite intrusions, and only differing from them in their exceptional composition.

IX.—The Term 'Hemera.'

By A. J. Jukes-Browne, B.A., F.G.S.

IN the December number of this Magazine Mr. Buckman complains that the use of his term *hemera* has been widely misunderstood. He says that it was never intended to be used for a subdivision of a zone, but solely as a chronological term to indicate the time during which the beds composing a *zone* were deposited, just as the term *age* is now generally accepted in a technical sense to mean the time during which a stage was deposited.

As one of those who must plead guilty to having misunderstood Mr. Buckman, I should like to explain how it is that he seems to have laid himself open to misapprehension. To put it briefly, Mr. Buckman, in his original paper of 1893, used the term *hemera*, not merely as a chronological term (though he defined it as such), but also as serving to represent a subdivision of a zone; for in two of his tables he used it as a stratigraphical division, and consequently it is his own fault if others supposed he meant it to be used in a stratigraphical sense, in spite of his own words about its chronological meaning.

That this was the immediate effect of his paper is proved by the report of the discussion upon it, in which the President spoke of "subzones or emata,"[1] and Mr. Winwood protested against the proposed term, saying that "if Mr. Buckman found it necessary to

[1] The word originally suggested was *emar*, subsequently altered to *hemera*.

subdivide his zones in that typical district, might not 'horizon' or 'subzone' answer his purpose equally well." [1]

What Mr. Buckman had really felt the want of was unquestionably a term to express a subdivision of a zone; others also have felt that want, and would have been grateful to Mr. Buckman for a handy word applicable in a strictly stratigraphical sense. Instead of this, however, he proposed a time-word, and further complicated the matter by saying that "it is for a palæontological purpose similar to Moore's use of zone that I propose the term hemera," having just above stated that Moore confined his use of the word zone "to the exact horizon of a particular fossil" (op. cit., p. 481). From this anyone might conclude that the term hemera was meant to indicate both a palæontological horizon and the time of its formation, especially as he does not use any other term for his stratigraphical unit except the phrase "strata of the hemera." Moreover, in his correlation table facing p. 514, he gives the vertical succession of beds at different places, and numbers them according to a vertical succession of hemera given in parallel columns: what is this but a use of the term hemera as a stratigraphical unit?

Again, on p. 519 there is a table entitled "Correlation of the Zones and Hemeræ," in which the latter are clearly shown to be equivalent to parts of a zone. On p. 481 of the same paper he accepts the word zone as "the stratum or strata characterized by an assemblage of organic remains"; hence it is clear that he did not use the word zone as a division of time, but of vertical thickness. Now if hemera are parts of a zone they are stratigraphical units, not time-units; what, then, becomes of Mr. Buckman's assertion that he proposed the term hemera to denote the time occupied by the formation of a zone?

Mr. Buckman says that "much of the trouble about zones and hemeræ has arisen from attempts to make the term 'zone' a kind of 'portmanteau word,' one into which several meanings were to be packed," but his further proposals would only, in my opinion, make things worse than they are now. By general consensus, as I have shown elsewhere, a zone in its geological sense is a stratigraphical term, and a subzone is a subdivision of a zone, so that we do not want the word 'hemera' in that sense, and I do not think that the term *subfaunizone* would meet with acceptance.

The term hemera may, however, be occasionally convenient to signify the duration of a subzone, as age signifies the duration of a stage, but if we want to avoid confusion we must not speak of the hemera of a zone. For this another word should be coined, and if one is really necessary I would suggest that the Latin word *seculum* will furnish us with 'secule,' which finds an actual French equivalent in *siècle*.

I submit, therefore, that the awkward words 'biozone' and 'faunizone' are quite unnecessary, and certainly do nothing to dispel the ambiguity in the meaning and use of the term 'hemera.' I think that all requirements would be met by the use of the following

[1] Quart. Journ. Geol. Soc., vol. xlix, p. 522.

terms, which simply extend the accepted geological scale into more minute units of thickness and time. Thus—

A *stage* represents an *age*.
A *zone* represents a *secule*.
A *subzone* represents a *hemera*.

Mr. Buckman's use of the term hemera with the specific name of a fossil in front of it may very well be adopted as a shorter phrase than the full expression of the subzone; thus we may write of the '*concavi*-hemera' as short for the "hemera of the subzone of *Lioceras concavum*," but the stratum containing this Ammonite is a subzone, not a hemera nor a zone.

REVIEWS.

MÉMOIRES POUR SERVIR À L'EXPLICATION DE LA CARTE GÉOLOGIQUE DÉTAILLÉE DE LA FRANCE. (*a*) RECHERCHES SUR LA CRAIE SUPÉRIEURE (première partie), par A. DE GROSSOUVRE, avec (*b*) une monographie de genre *MICRASTER* par J. LAMBERT. 4to; in two Fasciculi with 1,013 pages, 33 figures and maps, and 3 plates. (Paris, 1901.)

THOUGH both the fasciculi of this work bear the date 1901 they do not seem to have been distributed until 1902. The scope of the treatise is considerable, for under the title of "Craie Supérieure" the author includes the Turonien, Senonien, and Maestrichtien divisions of the Chalk throughout western and central Europe, with chapters on the Chalk of India and the United States. These are followed by an essay on the classification of the Upper Cretaceous Series, and by another on the History of the Earth with especial reference to that of Cretaceous Time. Moreover, some space is devoted to a monograph on the genus *Micraster* written by M. J. Lambert.

It is evident, therefore, that in these volumes we have the results of a detailed and comparative study of what has been discovered and written about this portion of the Cretaceous System, not only in France but in many other countries. The work does indeed furnish the reader with an enormous amount of information, the greater part of which is a careful compilation from the most authoritative sources available at the time of writing; each chapter contains one or more tabular correlations of the strata described therein, and also tabulated lists of the Cephalopoda and Echinoderms showing the vertical distribution of each species.

Moreover, in those chapters which call for the exercise of original thought and the critical faculty we are pleased to find that M. de Grossouvre is a careful balancer of evidence, that he seldom takes an extreme view on any debateable question, but generally takes a comprehensive grasp of its several aspects. Consequently his opinions and conclusions deserve serious consideration, whether they happen to fall in with the reader's views or not.

The treatise will undoubtedly be useful to every student of the Cretaceous System, though of course some portions are of less value

than others, and it suffers as a whole from the fact that its component parts have been printed off in successive years from 1895 to 1901. The author states this in order to explain his omission to notice the numerous publications on the Chalk which have appeared since the earlier chapters of his monograph were printed off. Thus the account of the Chalk of England and Ireland which forms Chapter v is much behind the knowledge of the day; it is short and taken almost entirely from Prof. Barrois' "Recherches" (published in 1876), which was excellent at that date, but has since been corrected and improved upon in many particulars. A great thickness is attributed to the zone of *Marsupites*, while that of *Actinocamax quadratus* is said to be little developed in England, the fact being that the greater part of Prof. Barrois' zone of *Marsupites* is really referable to the zone of *Actinocamax quadratus*.

The Chalk of France (i.e. the Turonian and Senonian stages) is described in considerable detail, separate chapters being given to the following areas: the Paris Basin, Hainault and Limbourg, Touraine, Aquitaine, the Pyrenees, the valley of the Rhone, Provence, and the Western Alps. The chapter on the Paris Basin, however, does not include any adequate account of the Chalk of Normandy, which indeed is hardly mentioned; the reason of this is that since Hébert's time no French geologist has examined the fine chalk cliffs of Fécamp, St. Valerie, and Dieppe, that consequently the materials for a zonal description of this area do not exist, and M. de Grossouvre has been obliged to omit it from his purview. It is to be hoped that he or some other capable geologist from France or England will ere long make good this regrettable hiatus in our knowledge of the Chalk of the Anglo-Parisian region.

Other chapters deal with the Chalk (generally including the Cenomanian) of the Central Alps, the Eastern Alps, Bavaria, Bohemia, North Germany, Scandinavia, India, and the United States.

Besides these there are four chapters which discuss questions of general interest, and there is M. Lambert's essay on the genus *Micraster*. Of these chapters I propose to give some brief review.

Chapter i deals with stratigraphical methods and need not detain us long. In it the author states his dissent from the method generally employed in the correlation of strata, and especially of zones, i.e., the method of comparing assemblages of characteristic fossils including species of many different kinds of animals. This, he says, has led to many errors, and after reviewing various animal groups he concludes that Cephalopoda, and especially the Ammonoidea, are the only group that provides us with a sufficiently rapid succession of forms to furnish a dependable chronometric scale. "The method to be followed should be the same as in the Jurassic System, to begin with a chronometric scale based on the succession of Ammonite faunas, then by a comparison of a sufficient number of sections in different regions to establish the correlation of the beds in which Cephalopoda do not occur."

Chapter ii is entitled "Des Conditions de dépôt de la Craie Blanche." He refers to the antagonistic opinions which are held

upon this subject, some considering the Chalk to be a deep-water pelagic deposit, and others maintaining that it was formed in comparatively shallow water and not far from land. He constructs a table of the successive kinds of deposit which would normally be formed in an area which underwent extensive subsidence until it was covered by very deep water and then slowly rose again, and he shows that Cretaceous deposits found in the Paris Basin correspond with such a succession, that each stage indicates deeper water than that below, till in the Chalk with many flints we have a deposit formed in water of more than 500 metres and at a great distance from shore-lines.

He next examines the minute structure of Chalk, the Chalk fauna, and the composition of flints, quoting the opinions and observations of many authors. He concludes that white chalk must have been deposited in the central parts of a very extensive sea, the deepest part of which may have been about 1,000 metres (546 fathoms).

Chapter iv is M. Lambert's essay on the genus *Micraster*, but it is not easy to see why this should have been included in these volumes, which are described as the stratigraphical part of a more complete treatise. Moreover, since M. de Grossouvre relies mainly on Ammonites for his zonal classification one would have expected an essay on them rather than one on the Micrasters.

M. Lambert enumerates a large number of species, and considers between 30 and 40 of them to be good species, though not all of these occur in the Anglo-Parisian basin. He describes the species in the order of their creation, and not in the order of their affinities. He does not indicate the characters which he considers to be of specific importance, but seems to rely mainly on differences in general shape, in the characters of the ambulacral areas, and in the clearness of the subanal fasciole. He does not recognize the importance of the peristome, the labral plate, the tip of the labrum, and the periplastronal area, on each of which Dr. Rowe lays stress.

The general classification of the Upper Cretaceous Series occupies a long chapter. A preliminary discussion of principles leads the author to take D'Orbigny's names for his primary divisions or stages, and he also adopts most of Coquand's sub-stages, finally indicating what zones he would include in these several sub-stages. The indices of his zones are throughout species of Ammonites, and he expressly states that if Echinids were taken as guides the zones would not be the same.

Dealing first with the Cenomanian, he has necessarily to fix the limits of the stage, and more especially its lower limit. This, as he remarks, is a question which has often been debated, and which has recently been the subject of controversy between myself and M. G. Dollfus. After reviewing the difficulties the author decides in favour of the view which I have maintained; he puts aside the argument of the Cenomanian transgression as valueless, and while admitting that there are some localities where beds of passage exist and where "hesitation is admissible," he continues: "but this is not the case in the north of France, and if as a basis of classification

one relies entirely on the succession of Ammonite faunas, putting all other fossils aside, the gaize of Havre and that of Argonne will necessarily be excluded from the Cenomanien."

With regard to the upper limit of the stage, he says that it is almost everywhere clearly indicated by the disappearance of the *rotomagensis* group of the genus *Acanthoceras* and their replacement by the *ornatissimum* group, as well as by the appearance of *Pachydiscus peramplus* (which he refers to the genus *Neoptychites*). By this criterion he places the subzone of *Actinocamax plenus* in the Turonian, because M. Lambert has found *Pach. peramplus* in it at Dracy (Yonne), but in England *Acanth. rotomagensis* has been found in it and *Pach. peramplus* has not, so that by the same criterion we do right to retain the Belemnite marl in the Lower Chalk (Cenomanian).

For the Turonian he accepts D'Orbigny's definition of that stage in Touraine as including all the beds between the Cenomanian and the 'craie de Villedieu.' As the base of the latter appears to lie somewhere in what is usually called the zone of *Micraster cortestudinarium*, it is evident that, according to D'Orbigny and De Grossouvre, the Turonian should comprise the beds which have hitherto been known in France as the zones of *Inoceramus labiatus*, of *Terebratulina gracilis*, and of *Holaster planus*, with a portion of the zone of *Micraster cortestudinarium*. M. de Grossouvre, however, takes the Ammonoidea as his zonal guides, and divides his Turonian into four zones, which are grouped under two sub-stages thus :—

Turonien	Angoumien	zone of	*Acanthoceras Deveriæ.*
		,,	*Acanthoceras ornatissimum.*
	Saumurien	,,	*Acanthoceras Bizeti.*
		,,	*Mammites nodosoides.*

In the Senonian M. de Grossouvre groups all the higher Cretaceous beds which are found in France, and he divides the stage into two large sub-stages for which he adopts the names *Corbiérien* and *Campanien*, the former corresponding mainly with the zones of *Micraster coranguinum* and *Marsupites*, the latter with the zones of *Actinocamax quadratus* and *Belemnitella mucronata*. He regards the Maestrichtien of Belgium as only a facies of the craie de Meudon, and the Dordonien of Aquitaine as another facies of about the same age, so that both these divisions are brought within the limits of his Campanien.

Finally, he excludes the 'calcaire pisolitique' of France and the limestones of Saltholm and of Faxe from the Cretaceous system, on the ground that they contain no Ammonites. He places them, with the Montien of Belgium, as the basal portion of the Tertiary succession, though he hesitates to call them Eocene. In this he follows the Geological Survey of Belgium, who have created a 'Palæocene System' for their Montien, but it is generally admitted that the typical Danien is older than the Montien, and for myself I fail to see that the absence of Ammonites is a sufficient reason for excluding the Saltholm and Faxe beds from the Cretaceous system.

Returning to M. de Grossouvre's classification of the Senonian, there can be no doubt that he avoids some difficulties by taking

Cephalopoda alone as his guides, and in creating eight Ammonite zones in place of those usually adopted. Where species of Ammonites occur with sufficient frequency, these zones are no doubt more satisfactory than those based on Echinoderms, but it will be some time before they can be made practically applicable to the Upper Chalk of England, in which Ammonites are rare fossils. If they are ever adopted in this country it will only be after they are firmly established in the north of France, and after a more careful comparison of our Chalk with that of the Paris Basin.

M. de Grossouvre's final chapter on the History of the Cretaceous Period deals with nearly the whole of the Northern Hemisphere, and discusses the general distribution of land and water which existed in late Palæozoic and in Mesozoic times. It should be read by all who are interested in this subject, but the author's views and conclusions can hardly be summarized in a few lines.

A. J. Jukes-Browne.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 5th, 1902.—Prof. Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. From the Right Hon. the Secretary of State for the Colonies:—

"Curator, Botanic Station, St. Vincent, to Imperial Commissioner of Agriculture for the West Indies.

"Botanic Station, St. Vincent.
September 5th, 1902.

"Sir,—Cable communications of the eruption of the Soufrière on the 3rd and 4th inst. have doubtless reached you; nevertheless, I deem it my duty to forward you by this the earliest opportunity an official report on same:—

"Early on the afternoon of the 3rd inst. telephonic communications reached me that the Soufrière was agitated, and from the Botanic Station at about 2 p.m. on that day I observed certain white and dark clouds in the direction of the Soufrière, which from their upward movements convinced me that an eruption of the Soufrière was near at hand. At 3 p.m., the hour of taking observations at the Botanic Station in the afternoon, the corrected barometrical reading was 29·947 and the attached thermometer 85° F. The wind was blowing lightly from the north-east and the weather was bright. The only clouds were to the north, and the most conspicuous was a dark brown column, apparently over the Soufrière. At 5.30 p.m. I had a conversation with Mr. Nairn and Mr. Frederick at Montrose, and from the then appearances and sounds we were convinced that an eruption was pending. At about 8 p.m. I met in Kingstown Mr. H. Allen, Revenue Officer at Châteaubelair, who informed me that during the day he saw a lot of matter ejected over the western lip of the old crater down the Laricor or Roseau Valley to the sea. Mr. Allen and most of the residents of Châteaubelair left that place late in the afternoon for places of safety, and in the Georgetown District (Windward) the residents moved southward. At 9.55 p.m., as seen at the Botanic Station, the eruption commenced in earnest; flashes of flame and lightning were visible over the Soufrière at intervals of 20 to 30 seconds, with frequent longer intervals. At 10.30 p.m. the corrected reading of the mercurial barometer was 30·105 and the attached thermometer 81°·5 F. From about this hour the discharges and accompanying noises increased in frequency and severity, and at 1.30 a.m. (4th) the Soufrière was in full eruption. From this hour to 2 a.m. the eruption was, in the writer's opinion, more severe than on May 7th; the

explosions seeming to be louder and more continuous, and the electric discharges, owing doubtless to its being night, immeasurably grander and more awe-inspiring. The writer's house vibrated in a manner it did not do on May 7th. At 2 a.m. the corrected barometrical reading was 30·045 and the temperature 81° F., and at 3 a.m. the corrected reading was 30·035. The marvellous electric display was checked by a heavy shower from the east, and the roar was correspondingly lessened. From about 1·30 a.m. a cloud black as gunpowder was seen advancing southward from the Soufrière, and at 2·30 this cloud had assumed a circular form and was overhead of the Botanic Station. The discharges from this cloud and to northward were exceedingly numerous and severe, and the appearance generally was as though myriads of long fiery serpents were darting hither and thither, and a constant cracking noise was heard, in addition to the roar of the volcano. The chief disturbances seemed to be west of the Soufrière, in the direction of Martinique; and the writer is strongly of opinion, from observations at the time, that Mont Pelé and the Soufrière were in action together, but so far no news has come from Martinique. At 3 a.m. (4th) the discharges and roar to the west nearly subsided, and the Soufrière alone seemed in action, but more on the Windward side. From 3 to 4 a.m. the eruption gradually slackened, and at the latter hour had nearly ceased. The next morning the barometer was normal at 29·950, but the morning had a weird and gloomy appearance. No ashes or pebbles fell at the Botanic Station. No deaths are reported anywhere, and no damage to Windward, but to Leeward I learn on good authority that places partly untouched on May 7th are now very severely injured—for instance, the arrowroot-fields at Richmond Vale and Petit Bordelle and Sharpes, as well as the sugar-canes at the first-named, are extensively damaged by the thick coarse layer of material, and as far down as the Linley Estates and Cumberland extensive damage to ground provisions and arrowroot is reported. The principal peasant allotments are on the Linley Estates, and early to-morrow morning (6th) I am going with Mr. Osment to inspect these erstwhile thriving places. His Honour the Administrator is also visiting the Leeward District as far as Châteaubelair to-morrow. We had made arrangements for distributing some thousands of economic plants to the Leeward allottees during the coming week, but I fear that this is now out of the question, as the holders have reported that their provisions are buried deep. Last night we had one of the worst thunderstorms experienced here during the last 12 years, though the rainfall was only ·44 inch. I enclose for your further information a copy of the *Times* newspaper, so far the only one issued this week, and on my return from Leeward I hope to be able to give further facts.

"I have, etc.

(Signed) H. Powell,
Curator.

"Dr. D. Morris, C.M.G.,
Imperial Commissioner of Agriculture
for the West Indies."

2. A second communication (also received through the Secretary of State for the Colonies) was read, dated Grenada, September 23rd, from Sir R. B. Llewelyn, Governor of the Windward Islands, expressing the hope that some scientific observers might be induced to go out to the West Indies and settle there for some time, in order to accumulate information as to volcanic and kindred phenomena.

3. "The Fossil Flora of the Cumberland Coalfield, and the Palæobotanical Evidence with regard to the Age of the Beds." By E. A. Newell Arber, Esq., M.A., F.G.S.

The succession of Upper Carboniferous rocks in the region in question is apparently twofold: an essentially arenaceous series, at least 600 feet thick, consisting of massive sandstones alternating with shales and fireclays, overlying argillaceous and carbonaceous deposits; the latter forming the productive portion of the coalfield and containing three great coal-seams, traceable throughout the district, although known locally under different names. The Upper or Sandstone Series has yielded very few plant-remains from its

upper division, but from the lower division a long list is given of plants collected by the author or preserved in the Woodwardian Museum. A second list of plants, from the upper division of the Carbonaceous Series, is also given, nearly all the specimens having been collected by the author. The consideration of the palæobotanical evidence enables him to classify the rocks as follows:—

Permian.	Brockram.		Lower Permian.
Upper Carboniferous	Sandstone Series.	Upper	(?) Transition Coal-measures
		Lower	
	Productive measures.	Upper (Bannock and Main Bands).	Middle Coal-measures.
		Lower (?)	(?) Lower Coal-measures and Millstone Grit.

4. "Some Remarks upon Mr. E. A. Newell Arber's Communication: On the Clarke Collection of Fossil Plants from New South Wales." By Dr. F. Kurtz, Professor of Botany in the University of Córdoba, Argentine Republic. (Communicated by A. C. Seward, Esq., M.A., F.R.S., F.G.S.)

The author agrees with Mr. Arber's identification of *Rhiptozamites Goepperti*, which he takes to be a synonym of *Noeggerathiopsis Hislopi*. *Podozamites elongatus*, however, he regards as different from *Noeggerathiopsis Hislopi*. Reasons are given for holding this opinion. Further, the author does not consider that there is sufficient evidence to warrant the separation of *Otopteris ovata* from *Rhacopteris inæquilatera*, in which species it may be retained, perhaps, as a variety. *Rh. inæquilatera* has been found in the Argentine, and was described by Geinitz as *Otopteris Argentina*. A bibliography is appended.

5. "On a new Boring at Caythorpe (Lincolnshire)." By Henry Preston, Esq., F.G.S.

This boring, after piercing Northampton Sands, passed through 199 feet of Upper Lias, 19 feet of Marlstone, and into the Middle Liassic Clays. With the aid of other shallow wells in the Lincolnshire Limestone the author shows that this rock has a decided dip to the west down the face of the escarpment, as though it had settled down upon the eroded surface of the Upper Liassic Clay. This settlement is probably the cause of a continuous spring flowing from the junction, and it has given rise to an underestimate of the thickness of the Upper Lias.

II.—November 19th, 1902.—Prof. Charles Lapworth, LL.D., F.R.S., President, in the Chair. The following communications were read:—

1. "The Semna Cataract or Rapid of the Nile: a Study in River-Erosion." By John Ball, Ph.D., F.G.S., A.R.S.M., Assoc. M. Inst. C.E.

Inscriptions placed on the rocks at Semna, between the second and third cataracts, under the Twelfth and Thirteenth Dynasties, serve as a means of gauging the local changes due to river-erosion during a period of about 4,200 years. Horner, in 1850, came to the conclusion that "the only hypotheses which could meet the requirements of the facts observed would be either the wearing away of a reef or barrier at the place in question—a process requiring too long a period—or the existence at some distant period of a dam or barrier, formed perhaps by a landslip of the banks, at some narrow gorge in the river's track below Semna." The author is in favour of the former explanation. The river, above and below the Kumna and Semna temples, has a width of 400 metres, but between the two temples a narrow band (200 metres wide) of hard red and grey gneiss contracts the river at low Nile within a central channel about 40 metres wide. Through this deep channel not less than 400 cubic metres of water pass per second. The gneiss itself, dykes of syenite-porphyry, hornblende-schists, and augitite are described; and it is shown that the foliation of the gneiss is parallel to the channel, and probably accounts for the direction of the latter. Rapid erosion with the formation of pot-holes is observed to be now taking place; and the author calculates that if 200 cubic metres (approximately 500 tons) of rock per year has been removed from the barrier, the lowering of it would amount to 2 millimetres a year, or in 4,200 years 7·9 metres, the depth of the present river below the lowest group of inscriptions dating from the time of Amenemhat III. The yearly discharge of the Nile past Semna is nearly 100,000 million tons of water; and the author considers that the removal of 500 tons of rock under existing conditions in a year is not only not impossible, but highly probable, as all this erosion only amounts to 5 milligrams of rock per ton of silt-laden water. This erosion is compared with the classic instance of the River Simeto in Sicily. At Assuan and Silsilla the river has suffered considerable lowering within geologically recent times, probably brought about by the removal of long pre-existent hard barriers. The sluices of the new dam at Assuan may in the future give a quantitative determination of silt erosion in granite, and it would appear to be not difficult to ascertain at Semna the rate of pot-holing. The formation of new pot-holes $1\frac{1}{2}$ feet deep, in an artificial channel in rock in Sweden, has been observed to take place in 8 or 9 years, and the author hopes in future to attempt some measurements of this kind at Semna.

2. "Geological Notes on the North-West Provinces (Himalayan) of India." By Francis J. Stephens, Esq., F.G.S., A.I.M.M.

The country examined extends in a north-westerly direction across the line of strike, from the borders of Nepal and South-Eastern Kumaon to north of the Alakmunda River in the vicinity of Badrinath and the Marra Pass. The foothills consist of Tertiary clays and sandstones, the snowy ranges of gneissose, granitic, and metamorphic rocks of various descriptions. "Between the snowy ranges, or, rather, the most southerly range of the Himalaya chain, a band of hills extends, for nearly 50 miles on an average, to the

foothills." These have hardly been explored, though roughly mapped on geological maps of India as belonging to a "Transition Series." The whole area is rich in minerals. The author gives a brief description of various rocks, met with mainly in this third belt. They include slates with vein quartz; mica and graphite schists; dykes of dolerite; granites; clay-slates, sandstones, and schists, with copper, lead, and tin; limestones, serpentines, and hornblendic rocks, with talc, steatite, etc.; various schists, quartzites, and limestones. The summary of the author's observations leads him to "suppose that there are at least three distinct limestone or calcareous series in Kumaon and Garhwal, and that schists and quartzites, with several isolated patches of granitic rock, form a large part of the remaining formations."

3. "Tin and Tourmaline." By Donald A. MacAlister, Esq., F.G.S.

Cassiterite hardly ever occurs without tourmaline, though the latter is found without the former; hence it appears that tourmaline-producing constituents and influences are of wider range than are those of cassiterite. Boron-trioxide is an extremely common accompaniment of volcanic action, and there can be no doubt that it has acted powerfully in changing such original minerals as the micaceous and felspathic ingredients of crystalline rocks. From a comparison of formulæ representing tourmaline and felspar, it is evident that the act of tourmalinization has been accompanied by a loss of soda. The excess of this soda will combine with boric acid, forming metaborate and pyroborate of soda. The former, acting on disseminated tin-ore, might result in the production of sodium-metastannate and borax. The metastannate is soluble and capable of being leached out of the magma, and, by a new reaction, tin-oxide may be precipitated and concentrated, while sodium-metaborate may be liberated. According to the cooling-curve of solutions, in all probability deposition of the oxide of tin would take place more rapidly at a certain stage in the process of cooling than at others.

OBITUARY.

THE REV. THOMAS WILTSHIRE, M.A., D.Sc., F.L.S., F.G.S., F.R.A.S.,

EMERITUS PROFESSOR OF GEOLOGY, ETC., KING'S COLLEGE, LONDON.

BORN APRIL 21, 1826. DIED OCTOBER 27, 1902.

THOMAS WILTSHIRE was born in the City of London 21st April, 1826, and was the son of Mr. Sampson Coysgarne Wiltshire and of Sarah his wife (*née* Sarah Goodchild). He was educated at home by a private tutor, Mr. Burtt, and spent much of his spare time when a boy, as well as his pocket-money, in technical pursuits, being very skilful in all mechanical work and in the use of tools and apparatus of all kinds. He afterwards commenced as a student at

King's College, London, but at 19 he entered Trinity College, Cambridge, where he did well in Classics and Mathematics. Here, attending Professor Sedgwick's lectures, he developed a taste for geology, which continued to be the dominating pursuit of his after life. In 1849 he was duly elected on the Livery of the 'Clothworkers,' to which City Company he had been apprenticed seven years previously. He took his B.A. degree with honours on the 26th January, 1850, and in the following June was ordained a Deacon and became Curate of Riddings, Derbyshire. On the 22nd October, 1850, the young Deacon married Miss H. Hudson. His eldest son—Thomas Pemberton Wiltshire—was born on November 15th, 1851.

He took his M.A. degree in July, 1853, and on the 18th December of that year he was ordained a Priest. In 1855 the Rev. Thomas Wiltshire was appointed Sunday Evening Lecturer at the united parishes of St. Matthew's, Friday Street and St. Peter's, West Cheap. For many years he spent his Summer holidays at Folkestone, where he assiduously collected the fossils of the Gault and Grey Chalk, assisted in his labours by Griffith, the well-known collector. In other years he stayed at Niton and Ventnor, in the Isle of Wight, collecting from the Hard Chalk, Chloritic Marl, and Upper Greensand with Mr. Mark Norman; or working at the Red Chalk of Hunstanton with Westmoreland, the old lighthouse-keeper, or at the Chalk of Filey, in Yorkshire. From these historical localities, either with his own hands or aided by the local collectors, and likewise from that well-known old explorer of the Upper Chalk of Bromley, Kent, Jeremiah Simmonds, Mr. Wiltshire gradually accumulated a very fine collection of Cretaceous fossils, which about five or six years ago he presented to the Woodwardian Museum, Cambridge, where they are now preserved, together with the portrait of the donor.

In 1856 Mr. Wiltshire took his first scientific degree, by being elected a Fellow of the Geological Society of London, and in that year he, with other members, presented an address from the University of Cambridge to Her Majesty Queen Victoria at Buckingham Palace.

In 1857 he opened the first Sunday-school in the City of London at St. Nicholas Cole Abbey. On February 8th, 1859, Mr. Wiltshire was elected President of the newly-formed Geologists' Association, in succession to Toulmin Smith, Esq., its first President and one of the founders of the Association, which now numbers nearly 600 members, and was one of the first scientific societies to admit lady members and to accord to them equal privileges with the male sex. He was elected a Fellow of the Royal Astronomical Society in 1860, and of the Linnean Society in 1861. On the 4th April, 1859, Mr. Wiltshire read an excellent paper "On the Red Chalk of England" (see Proc. Geol. Assoc., vol. i, 1859–1865, p. 3, and *Geologist*, vol. ii, July, 1859, pp. 214 and 261–278). Mr. Wiltshire remained President of the Association from 1859 to 1862, and was re-elected and served from 1871 to 1873, when he was succeeded by Dr. Henry Woodward, F.R.S. In January, 1862, Mr. Wiltshire read

a paper "On the Ancient Flint Implements of Yorkshire, and the modern fabrication of similar specimens" (see Proc. Geol. Assoc., vol. i, pp. 215–226).

His friend Dr. J. S. Bowerbank, F.R.S., relinquished the Secretaryship of the Palæontographical Society in 1863, which he had held for 15 years, and the Rev. T. Wiltshire, M.A., F.G.S., was appointed in his stead, an office which he held until 1899, a period of 36 years, when he was followed by Dr. A. Smith Woodward, F.R.S. Mr. Wiltshire was also elected Secretary of the Ray Society in 1872, and continued to hold that post up to the time of his death. On his retirement from the Palæontographical Society, the two Societies presented him with an illuminated address, executed by Miss G. M. Woodward, his portrait in oil, by Miss Atkinson, and a cheque.

From his first home in Brompton he removed with his family to the Rectory, Bread Street Hill, E.C., in 1864, where he resided till about 1869, when, on its demolition, for City improvements, he migrated to 25, Granville Park, Lewisham, where he remained up to his death. In 1872 he acted as Lecturer in Geology for Professor Tennant at King's College for eight years. In 1880 Mr. Wiltshire filled the office of Dean for Evening Instruction; and on Professor Tennant's death in 1881 he was appointed Assistant Professor, and in 1890 Professor of Geology and Mineralogy, a post which he held until 1896, when upon his retirement, he was duly elected a Fellow and Emeritus Professor of King's College.

Mr. Wiltshire was one of the Honorary Secretaries of the Geological Society in 1874, an office which he filled until 1878. In 1882 he was selected for Treasurer to that Society, a post which he continued to hold until 1895, a period of 13 years.

In 1888 (following the order of succession after his election to the Livery in 1849, a period of 39 years) he became Master of the Clothworkers Company, the fifth most opulent Company in the City of London. Not only during his year of office, but when serving on the Court of Assistants, he frequently selected his geological and scientific associates to be the guests of the Company. He also assisted in distributing its numerous Charities.

After Mr. Wiltshire ceased his geological work, he spent his vacations in visiting Algiers, Iceland, Norway, and the Swiss Alps. In Switzerland, indeed, he spent several of his long Summer vacations. On four occasions he went to North America, taking in Canada, the United States, the Yellowstone Park, and the Rocky Mountains. On 27th April, 1899, the University of Cambridge conferred upon him the honorary degree of Doctor in Science (see Geol. Mag., June, 1899).

The Rev. Dr. Wiltshire performed the service and delivered his last Sunday evening lecture at St. Clement's, East Cheap, on the 26th October, returning home cheerfully to supper, his duty ended. The same night he passed quietly away from heart failure, after a busy life of 76 years. He now rests peacefully from his labours, leaving his widow, two sons and one daughter to mourn his loss.

H. W.